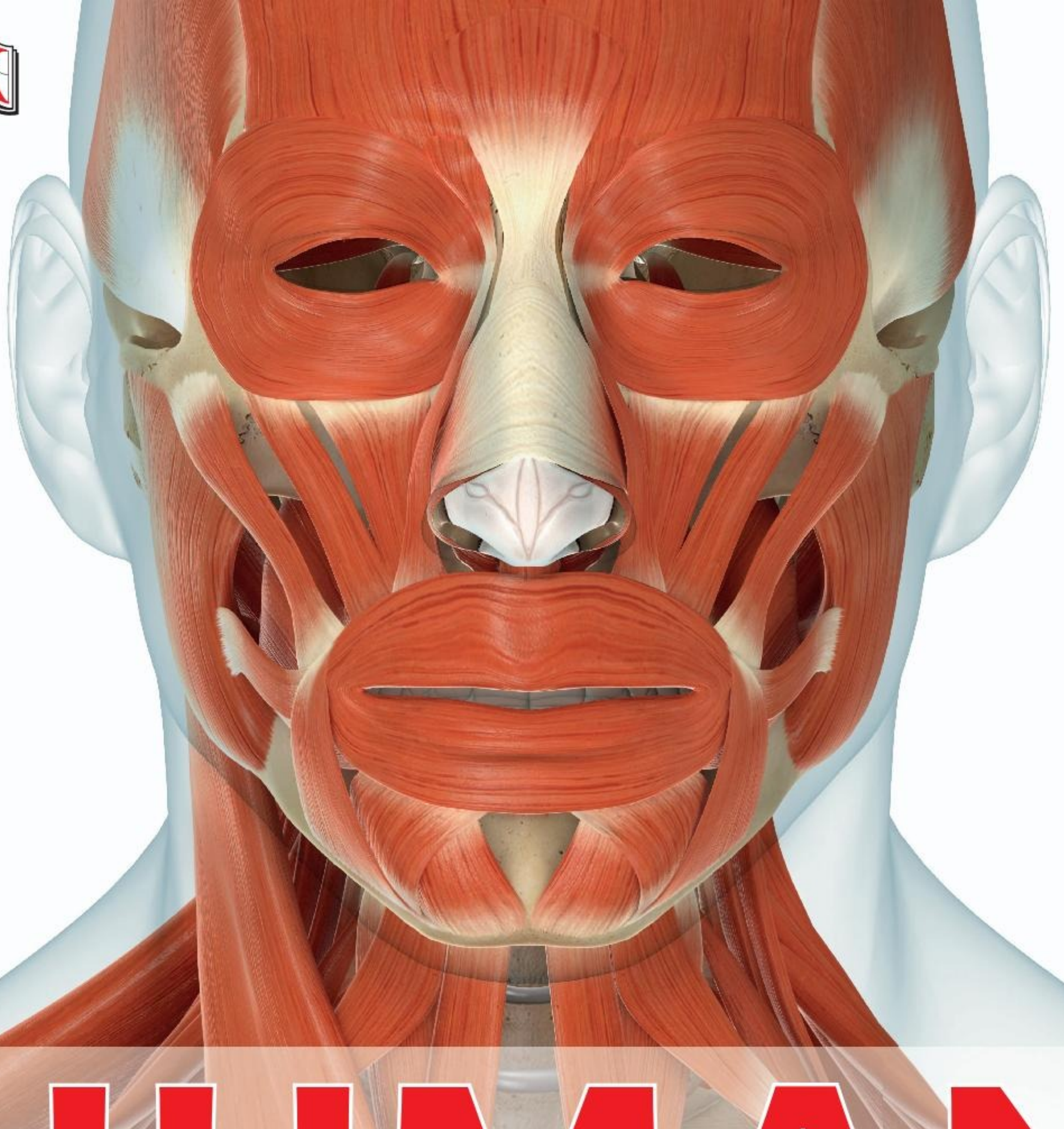

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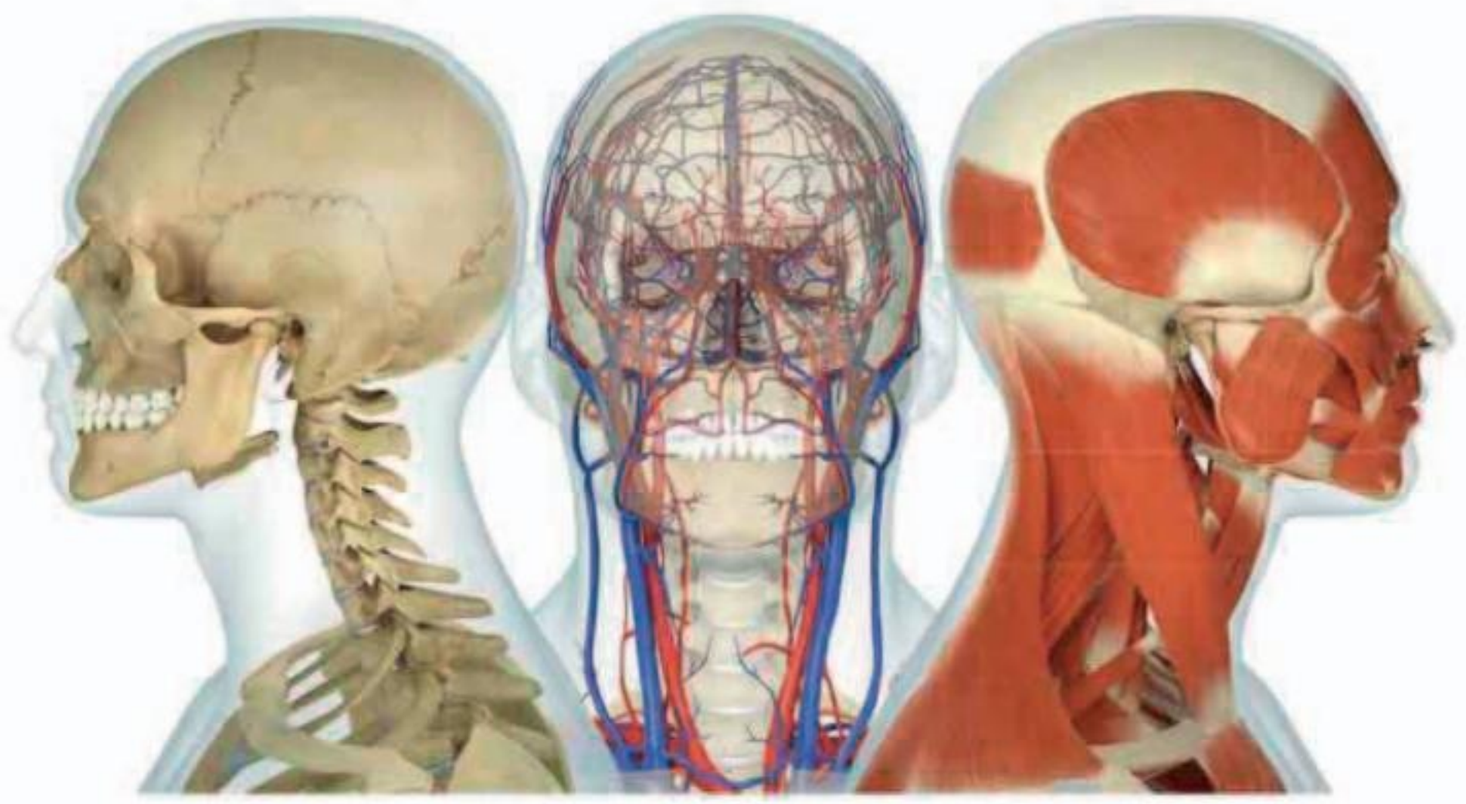

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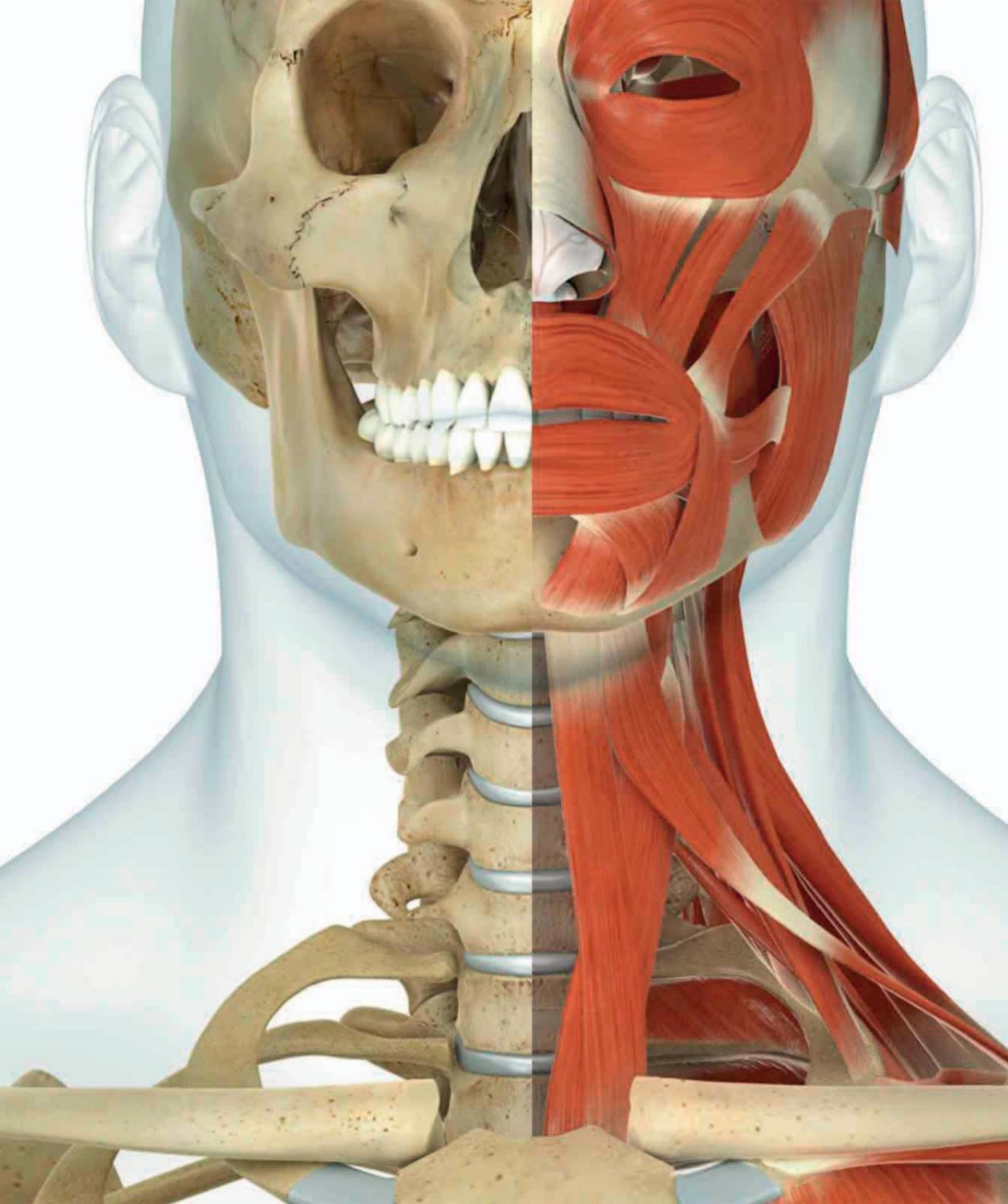

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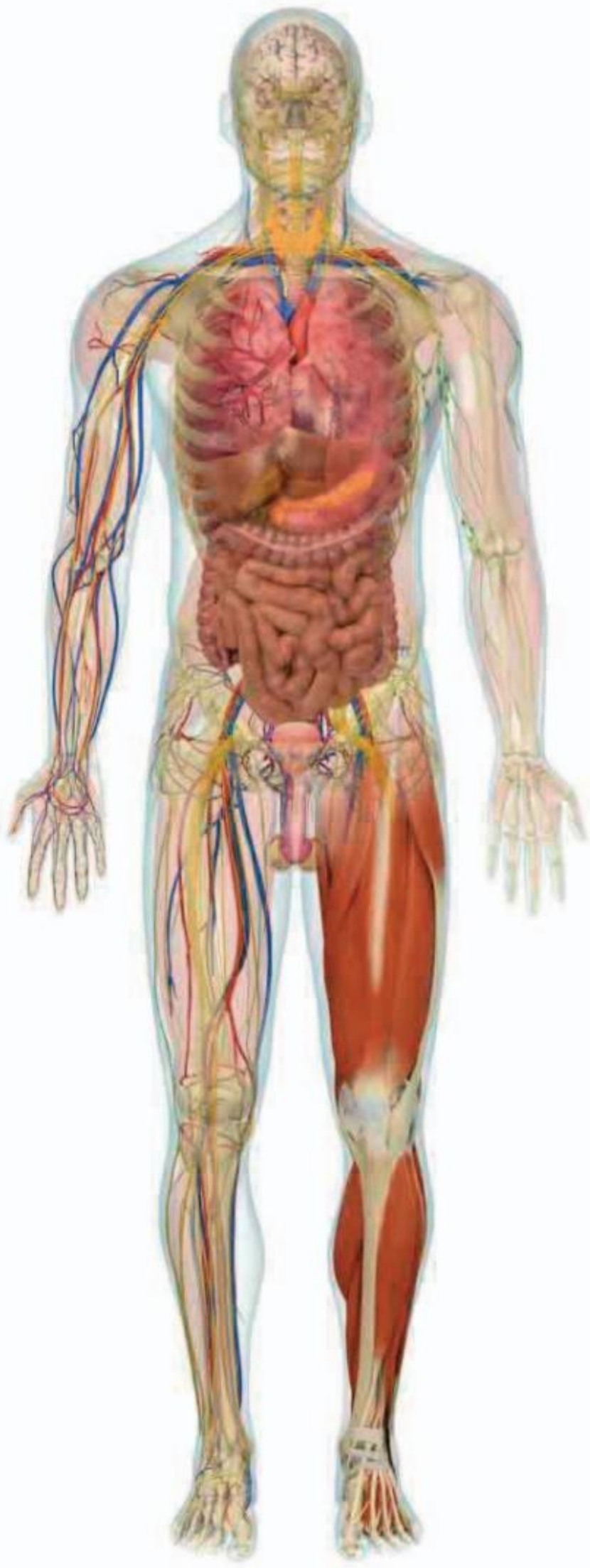

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FOREWORD

Anatomy is a very visual subject, and illustrated anatomy books have been around for centuries. In the same way that a map must represent the physical features of a landscape, anatomical illustrations must convey the detailed layout of the human body. The mapmaker is concerned with the topography of a landscape, while the anatomist focuses on the topography of the body. The maps—whether of landscapes or the body—are collected into books known as atlases. The first anatomical atlases appeared in the Renaissance period, but students of anatomy today still rely heavily on visual media. Plenty of students still use atlases, alongside electronic resources.

Anatomical depictions have changed through time, reflecting the development of anatomical knowledge, changing styles and taste, and the constraints of different media. One of the earliest and most well-known atlases is Andreas Vesalius' *De humani corporis fabrica* (On the structure of the human body), published in 1543. The anatomical illustrations in this book took the form of a series of posed, dissected figures standing against a landscape. It was a book intended not just for medical students, but for a general readership. The heavy use of images to convey information made sense for this visual subject, and also helped to make anatomy accessible.

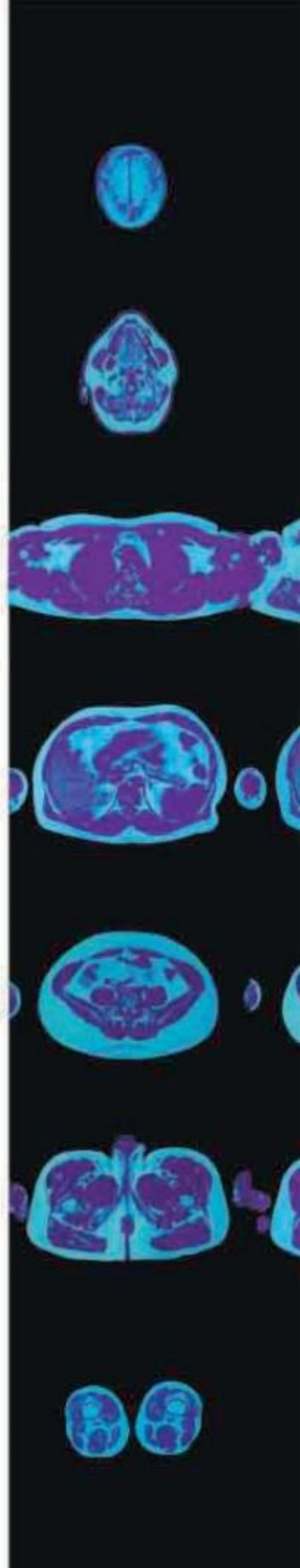
The late seventeenth century saw a striking change in anatomical depictions. Flayed figures, gracefully arranged against landscapes, gave way to brutally realistic illustrations of cadaveric specimens in the dissection room. The connection between anatomy and death was impossible to ignore in these pictures. The style of anatomy illustration has also been influenced by the methods available to capture and print images. As lithography replaced woodcut printing, it was possible to render anatomy in finer detail. Anatomical illustrators leaped on the potential offered by color printing, using different colors to pick out arteries, veins, and nerves. More recently, the advent of photography meant that anatomy could be captured more objectively. It would be reasonable to suppose that photography would offer the best solution to the challenges facing the medical illustrator, but the task requires more than objectivity and fidelity. Images need to be uncluttered, and sometimes a simple line drawing can convey information better than a photograph of an actual dissection. The challenge facing the medical illustrator has always centered on what to keep in and what to leave out.

The development of medical imaging, including the use of X-rays, ultrasound, and MRI (magnetic resonance imaging), has had a huge impact on medicine, and has also had a profound effect on the way we visualize and conceptualize the body. Some anatomy atlases are still based on photographic or drawn representations of dissected, cadaveric specimens, and these have their place. But a new style has emerged, heavily influenced by medical imaging, featuring living anatomy. The supernatural, reanimated skeletons and musclemen of the Renaissance anatomy atlases, and the later, somewhat brutal illustrations of dissected specimens, have been replaced with representations of the inner structure of a living woman or man.

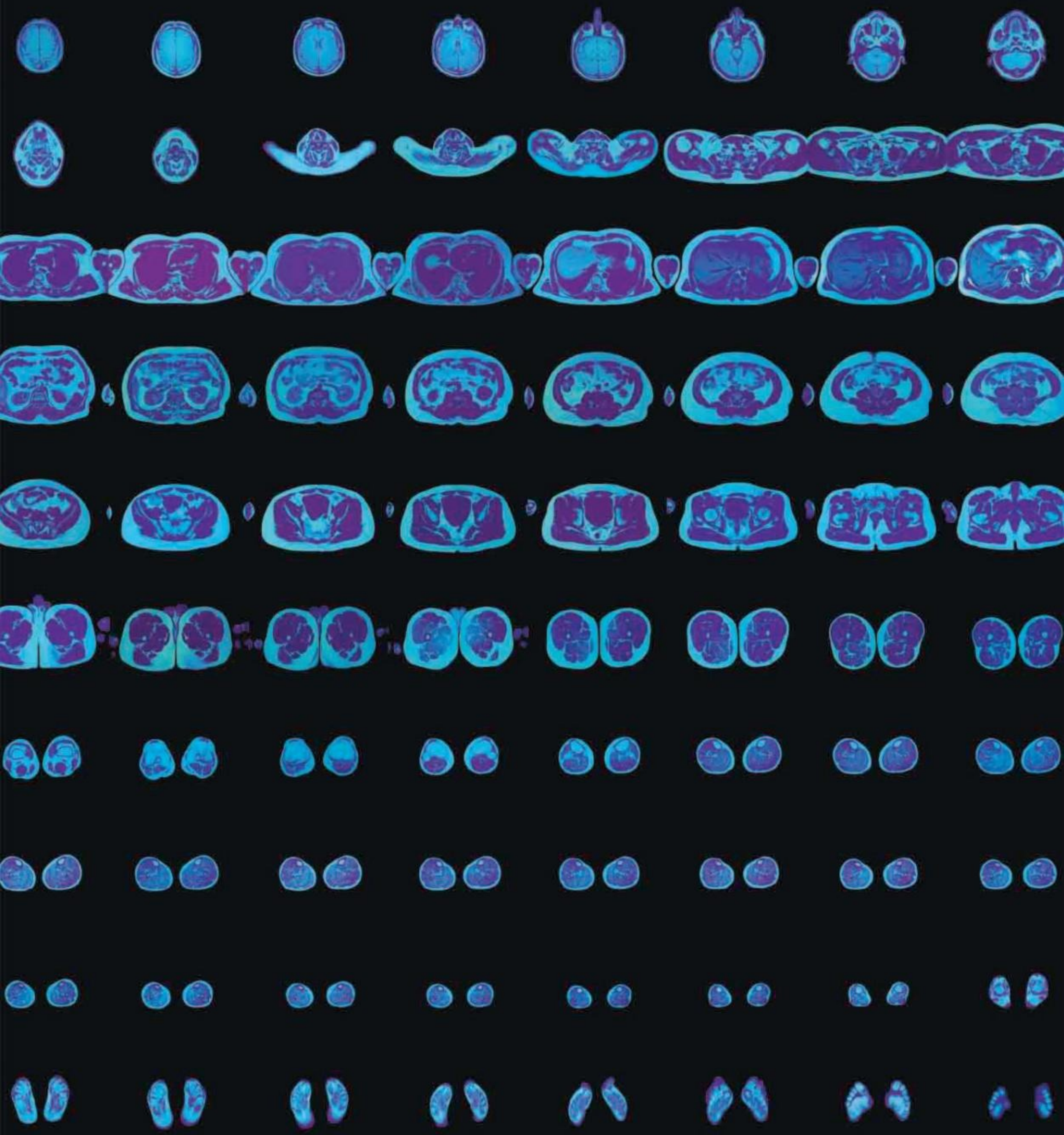
Historically, and by necessity, anatomy has been a morbid subject. The general reader may understandably have been put off by opening an atlas to be confronted with images of dead flesh, slightly shrunken eyeballs resting in dissected sockets, and dead guts spilling out of opened abdomens. But the depiction of living anatomy, informed by medical imaging techniques, reveals anatomy in all its glory, without the gore.

The illustrations in this atlas are all about living anatomy. Most of the images in this book are founded on a 3-D reconstruction of the anatomy of a whole body, drawn up in digital media and based on scans. We have grappled with the challenge of what to keep in and what to leave out. It's overwhelming to see all the elements at the same time, so the anatomy of this idealized living human is stripped down, revealing the bones, muscles, nerves, blood vessels, and organs of the body in turn. The result is, I hope, an anatomy atlas that will be useful to any student of anatomy as well as appealing to anyone with an interest in the structure of the human body.

PROFESSOR ALICE ROBERTS



The body piece by piece
A series of MRI scans show horizontal slices through the body, starting with the head and working downward, through the thorax and upper limbs, to the lower limbs and finally the feet.



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01 The Integrated Body

The human body comprises trillions of cells, each one a complex unit with intricate workings in itself. Cells are the building blocks of tissues, organs, and eventually, the integrated body systems that all interact—allowing us to function and survive.

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HUMAN GENETIC FORMULA

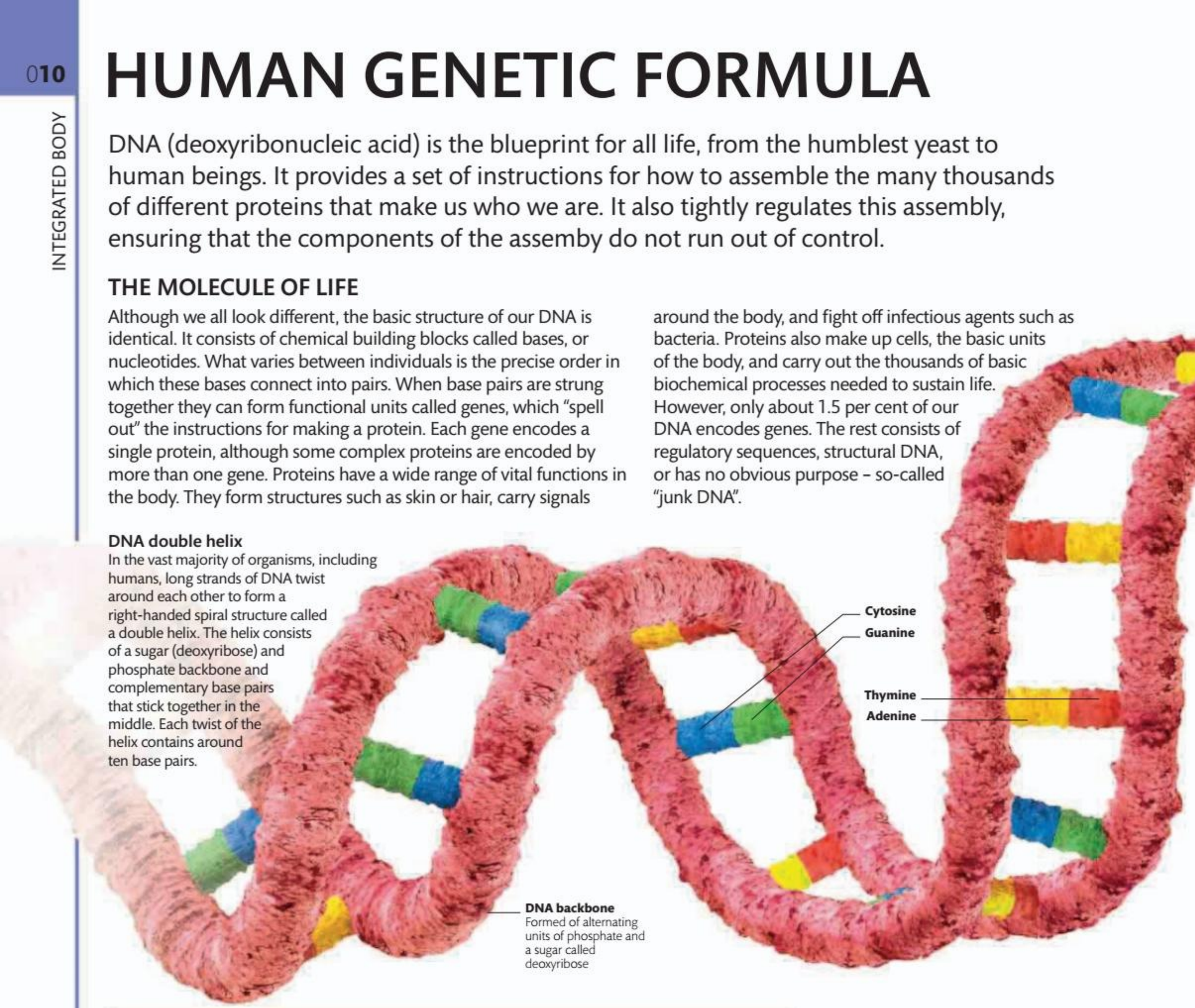
DNA (deoxyribonucleic acid) is the blueprint for all life, from the humblest yeast to human beings. It provides a set of instructions for how to assemble the many thousands of different proteins that make us who we are. It also tightly regulates this assembly, ensuring that the components of the assemby do not run out of control.

THE MOLECULE OF LIFE

Although we all look different, the basic structure of our DNA is identical. It consists of chemical building blocks called bases, or nucleotides. What varies between individuals is the precise order in which these bases connect into pairs. When base pairs are strung together they can form functional units called genes, which "spell out" the instructions for making a protein. Each gene encodes a single protein, although some complex proteins are encoded by more than one gene. Proteins have a wide range of vital functions in the body. They form structures such as skin or hair, carry signals around the body, and fight off infectious agents such as bacteria. Proteins also make up cells, the basic units of the body, and carry out the thousands of basic biochemical processes needed to sustain life. However, only about 1.5 per cent of our DNA encodes genes. The rest consists of regulatory sequences, structural DNA, or has no obvious purpose – so-called "junk DNA".

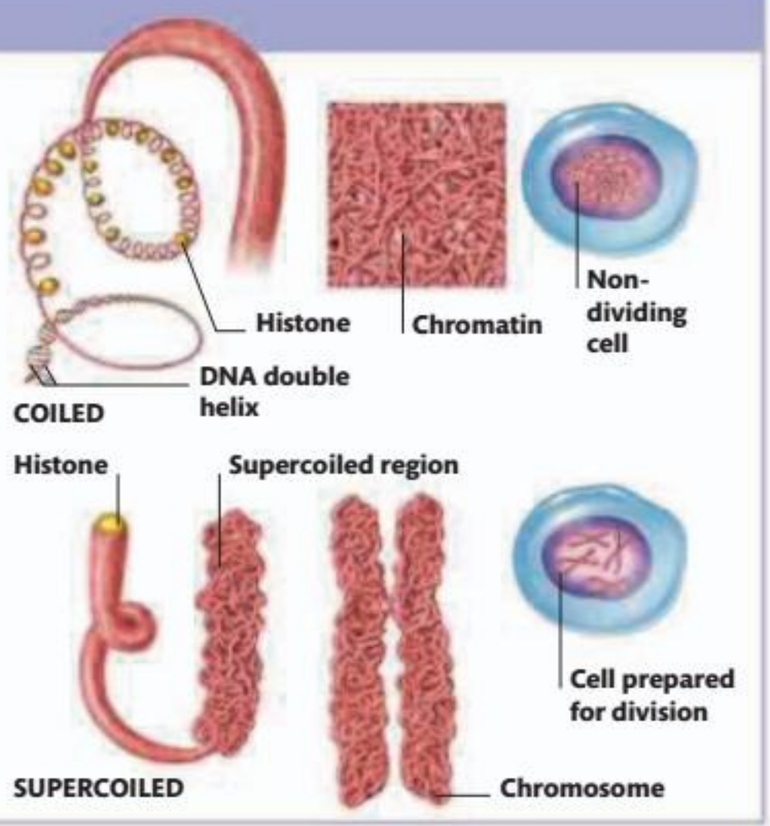
DNA double helix

In the vast majority of organisms, including humans, long strands of DNA twist around each other to form a right-handed spiral structure called a double helix. The helix consists of a sugar (deoxyribose) and phosphate backbone and complementary base pairs that stick together in the middle. Each twist of the helix contains around ten base pairs.



PACKAGING DNA

The human genome is composed of approximately 3 billion bases of DNA—about 6½ft (2m) of DNA in every cell if it were stretched from end to end. So our DNA must be packaged in order to fit inside each cell. DNA is concentrated into dense structures called chromosomes. Each cell has 23 pairs of chromosomes (46 in total)—one set from each parent. To package DNA, the double helix must first be coiled around histone proteins, forming a structure that looks like a string of beads. These histone "beads" wind around and lock together into densely coiled "chromatin", which, when a cell prepares to divide, further winds back on itself into tightly coiled chromosomes.



MAKING PROTEINS

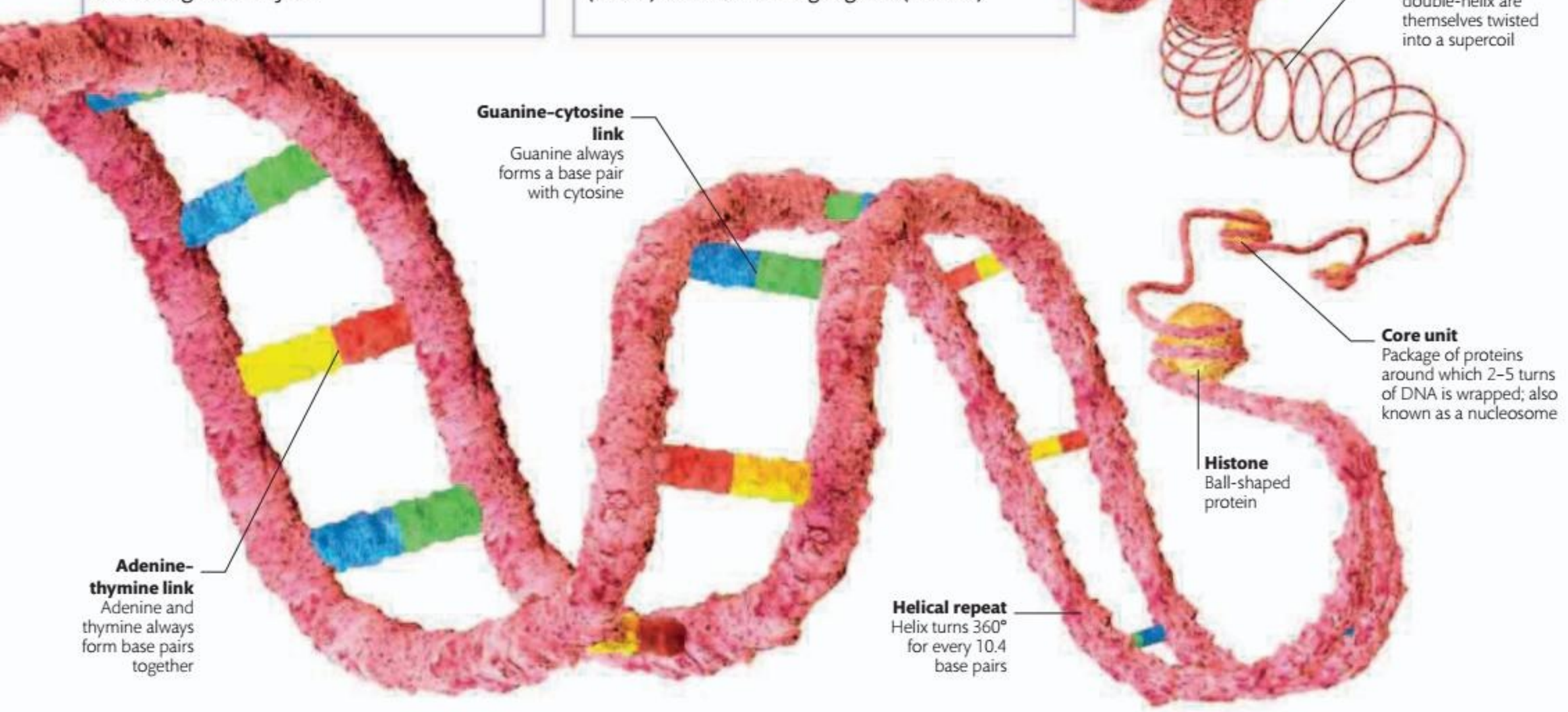
Proteins consist of building blocks called amino acids, strung together in chains and folded. Every three base pairs of DNA codes for one amino acid. The body makes 20 different amino acids—others are obtained from the diet. Protein synthesis occurs in two steps: transcription and translation. In transcription, the DNA double helix unwinds, exposing single-stranded DNA. Complementary sequences of a related molecule called RNA (ribonucleic acid) then create a copy of the DNA sequence that locks into the exposed DNA bases to be translated into protein. This "messenger RNA" travels to ribosomes, where it is translated into strings of amino acids. These are then folded into the 3D structure of a particular protein.

BASE PAIRS

DNA consists of building blocks called bases. There are four types: adenine (A), thymine (T), cytosine (C), and guanine (G). Each base is attached to a phosphate group and a deoxyribose sugar ring to form a nucleotide. In humans, bases pair up to form a double-stranded helix in which adenine pairs with thymine, and cytosine with guanine. The two strands are "complementary" to each other. Even if they are unwound and unzipped, they can realign and rejoin.

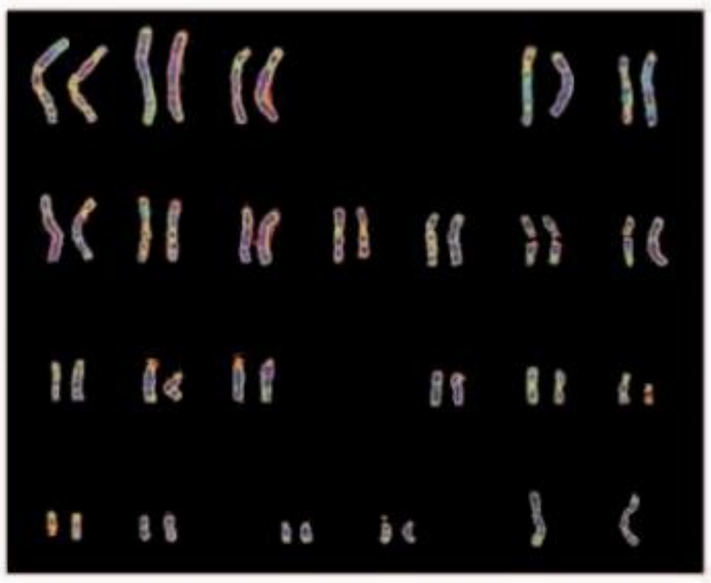
GENES

A gene is a unit of DNA needed to make a protein. Genes range in size from just a few hundred to millions of base pairs. They control our development, but are also switched on and off in response to environmental factors. For example, when an immune cell encounters a bacterium, genes are switched on that produce antibodies to destroy it. Gene expression is regulated by proteins that bind to regulatory sequences within each gene. Genes contain regions that are translated into protein (exons) and non-coding regions (introns).



THE HUMAN GENOME

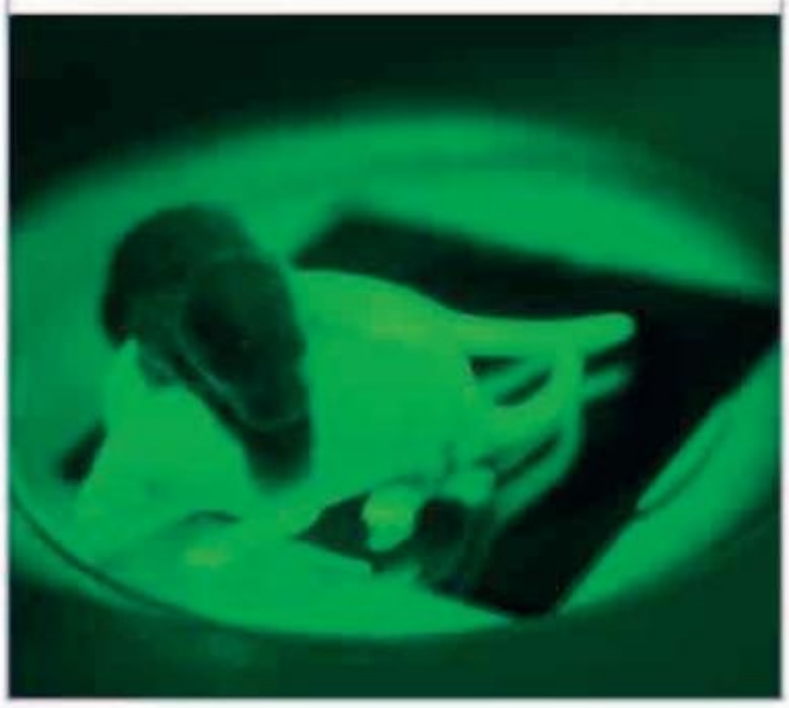
Different organisms contain different genes, but a surprisingly large proportion of genes are shared between organisms. For example, roughly half of the genes found in humans are also found in bananas. However, it would not be possible to substitute the banana version of a gene for a human one because variations in the order of the base pairs within each gene also distinguish us. Humans possess more or less the same genes, but many of the differences between individuals can be explained by subtle variations within each gene. In humans, DNA differs by only about 0.2 per cent, while human DNA differs from chimpanzee DNA by around 5 per cent. Human genes are divided unevenly between 23 pairs of chromosomes, and each chromosome consists of gene-rich and gene-poor sections. When chromosomes are stained, differences in these regions show up as light and dark bands, giving chromosomes a striped appearance. We still don't know the exact number of protein-coding genes in the human genome, but researchers currently estimate between 20,000 and 25,000.



Karyotype
This is an organized profile of the chromosomes in someone's cells, arranged by size. Studying someone's karyotype enables doctors to determine whether any chromosomes are missing or abnormal.

GENETIC ENGINEERING

This form of gene manipulation enables us to substitute a defective gene with a functional one, or introduce new genes. Glow-in-the-dark mice were created by introducing a jellyfish gene that encodes a fluorescent protein into the mouse genome. Finding safe ways of delivering replacement genes to the correct cells in humans could lead to cures for many types of inherited diseases—so-called gene therapy.



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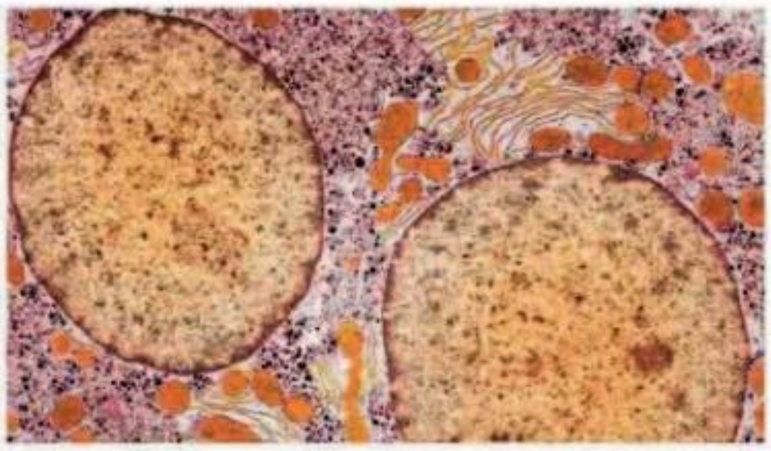
CELL

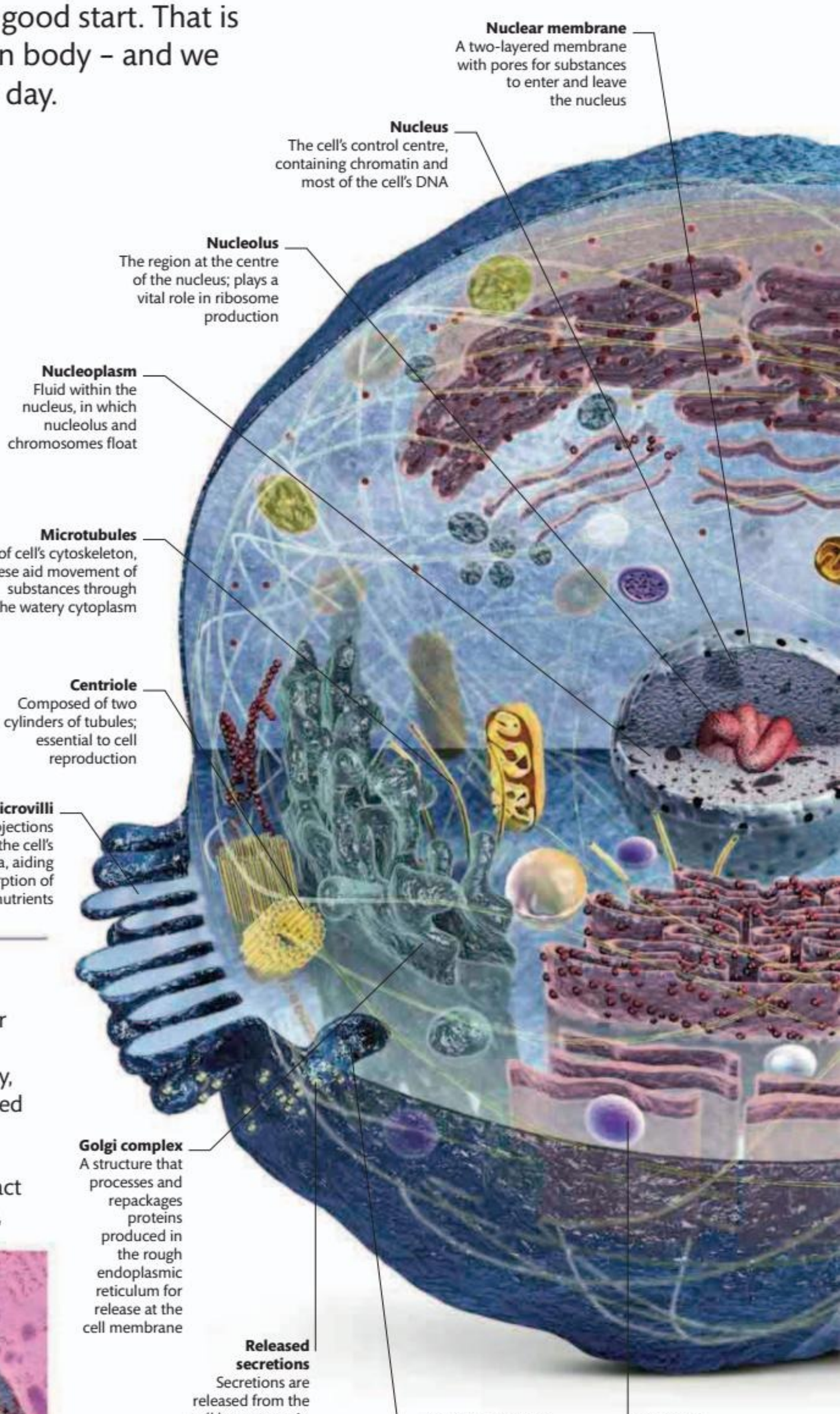
It is hard to comprehend what 75 trillion cells looks like, but observing yourself in a mirror would be a good start. That is how many cells exist in the average human body – and we replace millions of these cells every single day.

CELL ANATOMY

The cell is the basic functional unit of the human body. Cells are extremely small, typically only about 0.01mm across – even our largest cells are no bigger than the width of a human hair. They are also immensely versatile: some can form sheets like those in your skin or lining your mouth, while others can store or generate energy, such as fat and muscle cells. Despite their amazing diversity, there are certain features that all cells have in common, including an outer membrane, a control center called a nucleus, and tiny powerhouses called mitochondria.



Liver cell
These cells make protein, cholesterol, and bile, and detoxify and modify substances from the blood. This requires lots of energy, so liver cells are packed with mitochondria (orange).



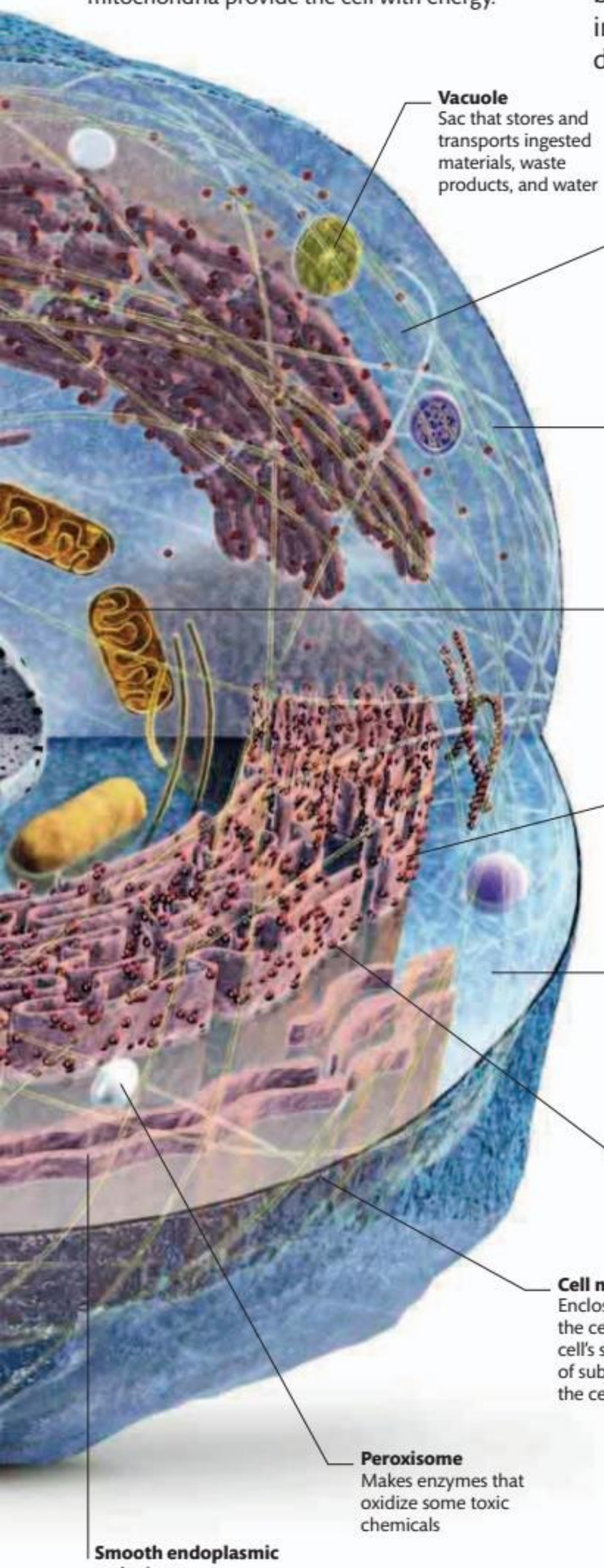
CELL METABOLISM

When a cell breaks down nutrients to generate energy for building new proteins or nucleic acids, it is known as cell metabolism. Cells use a variety of fuels to generate energy, but the most common one is glucose, which is transformed into adenosine triphosphate (ATP). This takes place in structures called mitochondria through a process called cellular respiration: enzymes within the mitochondria react with oxygen and glucose to produce ATP, carbon dioxide, and water. Energy is released when ATP is converted into adenoside diphosphate (ADP) via the loss of a phosphate group.

Mitochondrion
While the number of mitochondria varies between different cells, all have the same basic structure: an outer membrane and a highly folded inner membrane, where the production of energy actually takes place.

Generic cell

At a cell's heart is the nucleus, where the genetic material is stored and the first stages of protein synthesis occur. Cells also contain other structures for assembling proteins, including ribosomes, the endoplasmic reticulum, and the Golgi apparatus. The mitochondria provide the cell with energy.



Vacuole
Sac that stores and transports ingested materials, waste products, and water

Cytoskeleton
Internal framework of the cell, made up of microfilaments and hollow microtubules

Microfilament
Provides support for the cell; sometimes linked to the cell's outer membrane

Mitochondrion
Site of fat and sugar digestion in the cell; produces energy

Rough endoplasmic reticulum
Consists of folded membranes, studded with ribosomes, that extend throughout the cell

Cytoplasm
Jellylike fluid in which organelles float; primarily water, but also contains enzymes and amino acids

Ribosome
Tiny structure that assists with protein assembly (see p.10)

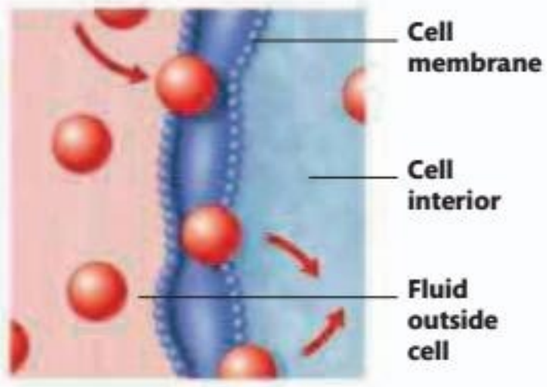
Cell membrane
Encloses contents of the cell and maintains the cell's shape; regulates flow of substances in and out of the cell

Peroxisome
Makes enzymes that oxidize some toxic chemicals

Smooth endoplasmic reticulum
Network of tubes and flat, curved sacs that helps to transport materials through the cell; site of calcium storage; main location of fat metabolism

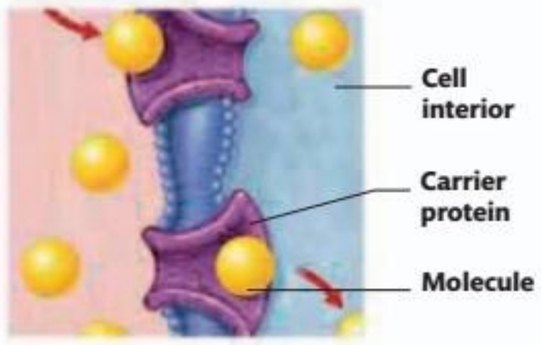
CELL TRANSPORT

Materials are constantly being transported in and out of the cell via the cell membrane. Such materials include fuel for generating energy, or building blocks for protein assembly. Some cells secrete signalling molecules to communicate with the rest of the body. The cell membrane is studded with proteins that help transport, allow cells to communicate, and identify a cell to other cells. The membrane is permeable to some molecules, but others need active transport through special channels in the membrane. Cells have three methods of transport: diffusion, facilitated diffusion, and active transport.



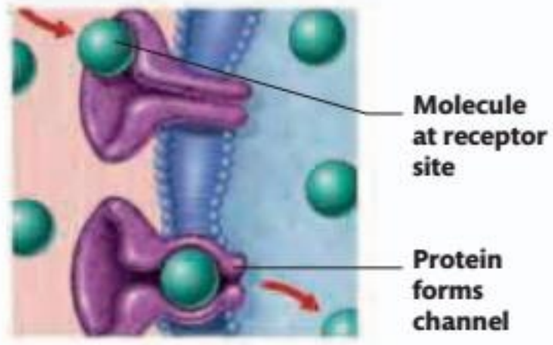
Diffusion

Molecules passively cross the membrane from areas of high to low concentration. Water and oxygen both cross by diffusion.



Facilitated diffusion

A carrier protein, or protein pore, binds with a molecule outside the cell, then changes shape and ejects the molecule into the cell.

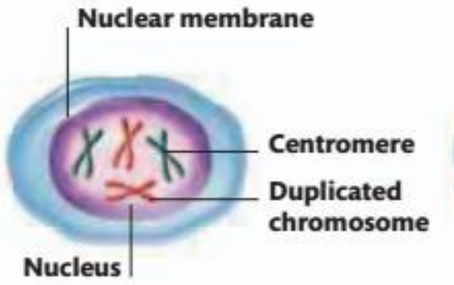


Active transport

Molecules bind to a receptor site on the cell membrane, triggering a protein, which changes into a channel that molecules travel through.

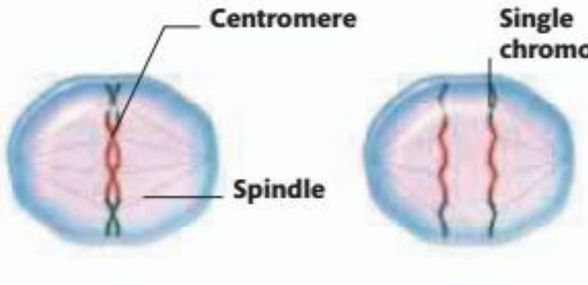
MAKING NEW BODY CELLS

While the cells lining the mouth are replaced every couple of days, some of the nerve cells in the brain have been there since before birth. Stem cells are specialized cells that constantly divide and give rise to new cells, such as blood cells. Cell division requires that a cell's DNA is accurately copied and then shared equally between two "daughter" cells, by a process called mitosis. The chromosomes are first replicated before being pulled to opposite ends of the cell. The cell then divides to produce two daughter cells, with the cytoplasm and organelles being shared between the two cells.



1 Preparation

The cell produces proteins and new organelles, and duplicates its DNA. The DNA condenses into X-shaped chromosomes.

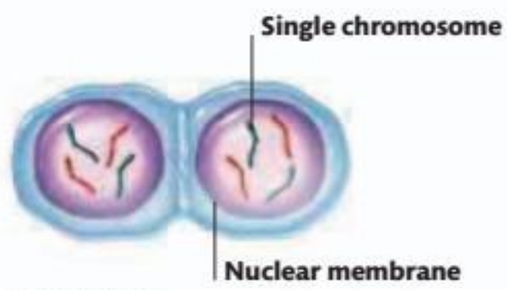


2 Alignment

The chromosomes line up along a network of filaments – spindle – linked to a larger network, called the cytoskeleton.

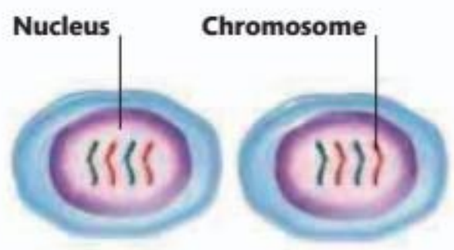
3 Separation

The chromosomes are pulled apart and move to opposite ends of the cell. Each end has an identical set of chromosomes.



4 Splitting

The cell now splits into two, with the cytoplasm, cell membrane, and remaining organelles being shared roughly equally between the two daughter cells.



5 Offspring

Each daughter cell contains a complete copy of the DNA from the parent cell; this enables it to continue growing, and eventually divide itself.

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BODY COMPOSITION

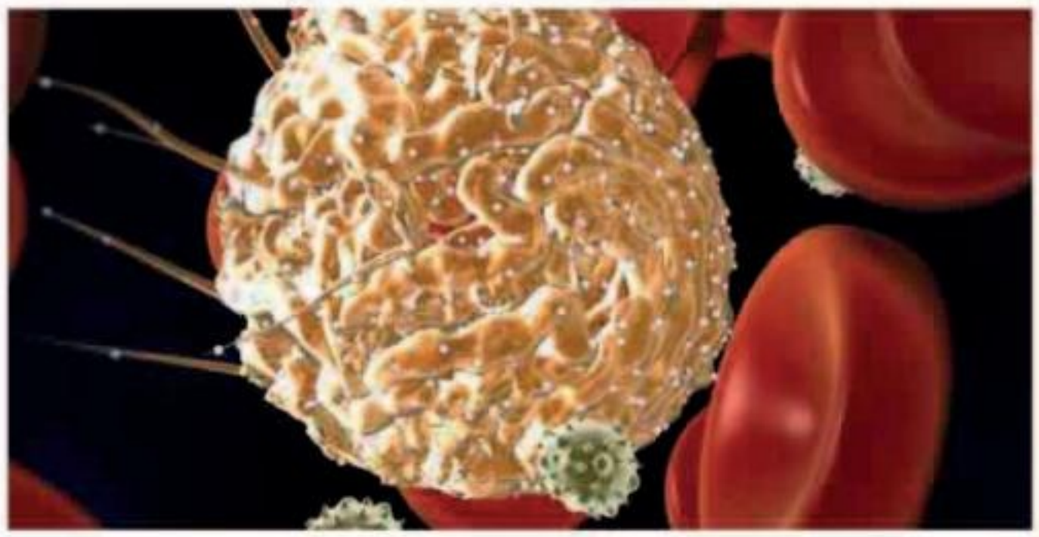
Cells are building blocks from which the human body is made. Some cells work alone—such as red blood cells, which carry oxygen—but many are organized into tissues. These tissues form organs, which in turn form specific body systems, where cells with various functions join forces to accomplish one or more tasks.

CELL TYPES

There are more than 200 types of cells in the body, each type specially adapted to its own particular function. Every cell contains the same genetic information, but not all of the genes are "switched on" in every cell. It is this pattern of gene expression that dictates the cell's appearance, its behavior, and its role in the body. A cell's fate is largely determined before birth, influenced by its position in the body and the cocktail of chemical messengers that it is exposed to in that environment. Early during development, stem cells begin to differentiate into three layers of specialized cells called the ectoderm, endoderm, and mesoderm. Cells of the ectoderm will form the skin and nails, the epithelial lining of the nose, mouth, and anus, the eyes, and the brain and spinal cord. Cells of the endoderm will become the inner linings of the digestive tract, the respiratory linings, and glandular organs. Mesoderm cells will develop into muscles, and the circulatory and excretory systems.

STEM CELLS

A few days after fertilization, an embryo consists of a ball of "embryonic stem cells" (ESCs). These cells have the potential to develop into any type of cell in the body. Scientists are trying to harness this property to grow replacement body parts. As the embryo grows, the stem cells become increasingly restricted in their potential and most are fully differentiated by the time we are born. Only a small number of stem cells remain in parts of the adult body, including in the bone marrow. Scientists believe that these cells could also be used to help cure diseases.



Adult stem cells
Adult stem cells, such as the large white cell in this image, are present in bone marrow, where they multiply and produce millions of blood cells, including red blood cells, also seen here.

Red blood cells
Unlike other cells, red blood cells lack a nucleus and organelles. Instead, they have an oxygen-carrying protein (hemoglobin), which gives blood its red color.

Epithelial cells
The skin cells and the cells lining the lungs and reproductive tracts are among the barrier cells, called epithelial cells, which line the cavities and surfaces of the body.

Adipose (fat) cells
These cells are highly adapted for storing fat – the bulk of their interior is taken up by a large droplet of semi-liquid fat. When we gain weight, they fill up with more fat.

Nerve cells
These electrically excitable cells transmit electrical signals down an extended stem called an axon. Found throughout the body, they enable us to feel sensations.

Photoreceptor cells
Located in the eye, these areof two types—cone and rod (left). Both have a light-sensitive pigment and generate electrical signals when struck by light, helping us see.

Smooth muscle cells
One of three types of muscle cell, smooth muscle cells are spindle-shaped cells found in the arteries and the digestive tract that produce contractions.

Ovum (egg) cells
The largest cells in the female human body, eggs are female reproductive cells. Like sperm, they have just 23 chromosomes.

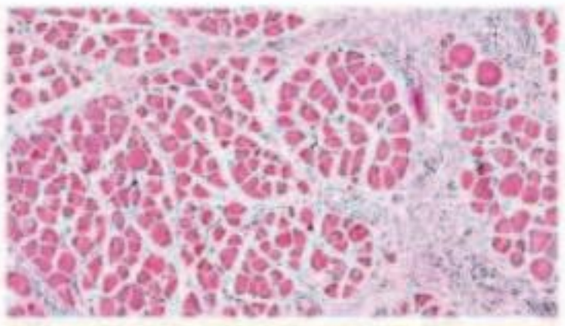
Sperm cells
Sperm are male reproductive cells, with tails that enable them to swim up the female reproductive tract and fertilize an egg.

LEVELS OF ORGANIZATION

The overall organization of the human body can be visualized as a hierarchy of levels. At its lowest are the body's basic chemical constituents, forming organic molecules, such as DNA, the key to life. As the hierarchy ascends, the number of components in each of its levels —cells, tissues, organs, and systems—decreases, culminating in a single being at its apex. Cells are the smallest living units, with each adapted to carry out a specific role, but not in isolation. Groups of similar cells form tissues, which in turn form organs with a specific role. Organs with a common purpose are linked within a system, such as the cardiovascular system, shown right. These interdependent systems combine to produce a human body (see pp.16–17).

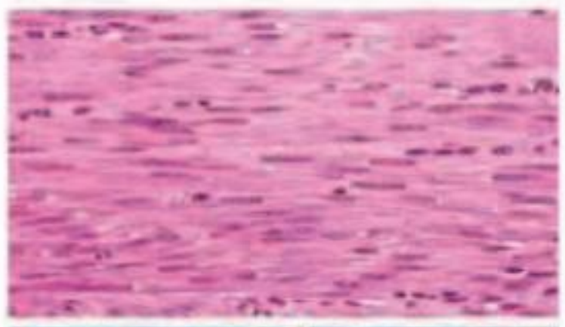
TISSUE TYPES

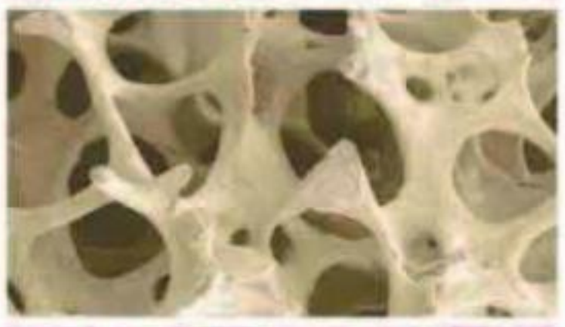
Cells of the same kind often group together to form tissues that carry out a specific function. However, not all cells within a tissue are necessarily identical. The four main types of tissue in the human body are muscle, connective tissue, nervous tissue, and epithelial tissue. Within these groups, different forms of these tissues can have very different appearances and functions. For example, blood, bone, and cartilage are all types of connective tissue, but so are fat layers, tendons, ligaments, and the fibrous tissue that holds organs and epithelial layers in place. Organs such as the heart and lungs are composed of several different kinds of tissue.



Skeletal muscle
This tissue enables voluntary limb movements. Its cells are arranged into bundles of fibers that connect to bones via tendons. They are packed with filaments that slide over one another to produce contractions.

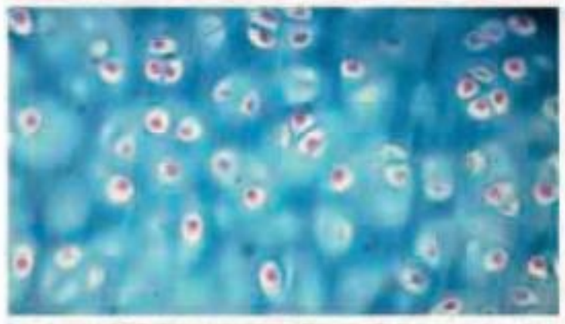
Smooth muscle
Able to contract involuntarily in long, wavelike motions, smooth muscle is found in sheets on the walls of specific organs. It is vital for maintaining blood pressure and for pushing food through the system.

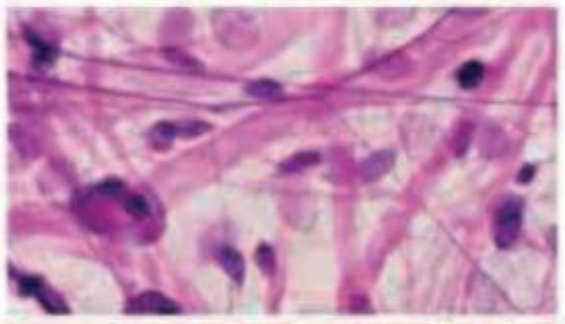




Spongy bone
Spongy bone is found in the center of bones (see p.24) and is softer and weaker than compact bone. The latticelike spaces in spongy bone are filled with bone marrow or connective tissue.

Cartilage
Its high water-content makes this tissue rubbery yet stiff. It is composed of cells, called chondrocytes, set in a matrix of gel-like materials secreted by the cells. Cartilage is found in the bone joints and in the ear and nose.



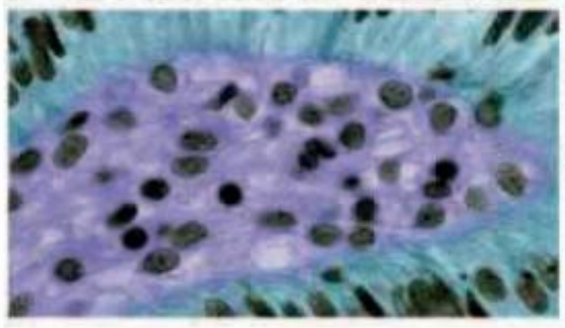


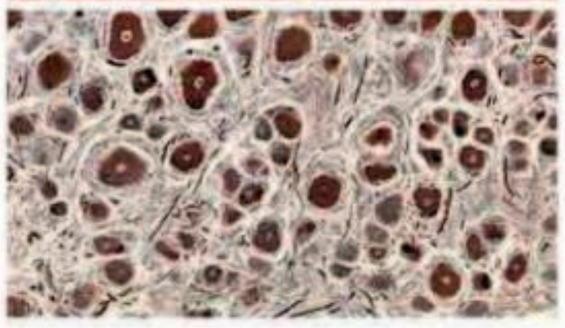
Loose connective tissue
This tissue type also contains cells called fibroblasts, which secrete loosely-organized fibers that make the tissue pliable. Loose connective tissue holds organs in place and provides support.

Dense connective tissue
This contains fibroblast cells, which secrete the fibrous protein called type 1 collagen. The fibers are organized into a regular parallel pattern, making the tissue very strong. This tissue type occurs in the base layer of skin.

Adipose tissue
A type of connective tissue, adipose tissue is composed of fat cells called adipocytes, as well as some immune cells, fibroblast cells, and blood vessels. Its main task is to store energy, and to protect and insulate the body.

Epithelial tissue
This tissue forms a covering or lining for internal and external body surfaces. Some epithelial tissues can secrete substances such as digestive enzymes; others can absorb substances like food or water.

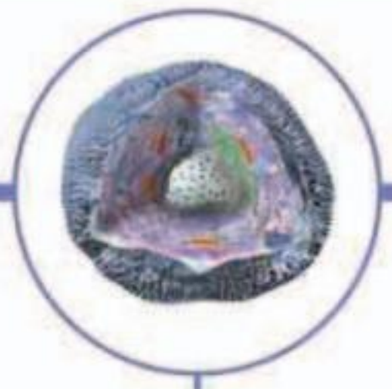




Nervous tissue
This forms the brain, spinal cord, and the nerves that control movement, transmit sensation, and regulate many body functions. It is mainly made up of networks of nerve cells (see opposite).

1. CHEMICALS

Key among the chemicals inside all cells is DNA (see pp.10–11). Its long molecules provide the instructions for making proteins. These, in turn, perform many roles, such as building cells.



2. CELLS

While cells may differ in size and shape, all have the same basic features: an outer membrane; organelles floating within jellylike cytoplasm; and a nucleus containing DNA (see pp.12–13).

3. HEART TISSUE

One of the three types of muscle tissue, cardiac muscle is found only in the walls of the heart. Its cells contract together, as a network, to make the heart squeeze and pump blood.

4. HEART

Like other organs, the heart is made of several types of tissue, including cardiac muscle tissue. Among the others are connective and epithelial tissues, found in the chambers and valves.

5. CARDIOVASCULAR SYSTEM

The heart, blood, and blood vessels form the cardiovascular system. Its main tasks are to pump blood, deliver nutrients, and remove waste from the tissue cells.

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BODY SYSTEMS

The human body can do many different things. It can digest food, think, move, even reproduce and create new life. Each of these tasks is performed by a different body system—a group of organs and tissues working together to complete that task. However, good health and body efficiency rely on the different body systems working together in harmony.

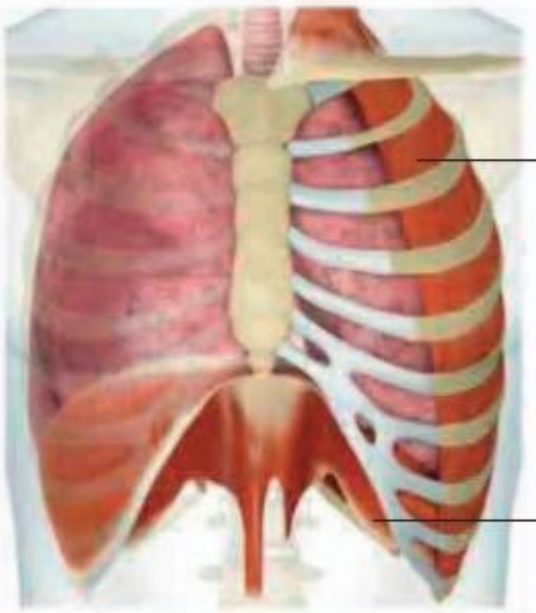
SYSTEM INTERACTION

Think about what your body is doing right now. You are breathing, your heart is beating, and your blood pressure is under control. You are also conscious and alert. If you were to start running, specialized cells called chemoreceptors would detect a change in your body's metabolic requirements and signal to the brain to release adrenaline. This would in turn signal the heart to beat faster, boosting blood circulation and providing more oxygen to the muscles. After a while, cells in the hypothalamus might detect an increase in temperature and send a signal to the skin to produce sweat, which would evaporate and cool you down.

The individual body systems are linked together by a vast network of positive and negative feedback loops. These use signalling molecules such as hormones and electrical impulses from nerves to maintain equilibrium. Here, the basic components and functions of each system are described, and examples of system interactions are examined.

BREATHING IN AND OUT

The mechanics of breathing rely upon an interaction between the respiratory and muscular systems. Together with three accessory muscles, the intercostal muscles and the diaphragm contract to increase the volume of the chest cavity. This draws air down into the lungs. A different set of muscles is used during forced exhalation. These rapidly compress the chest cavity, forcing air out of the lungs.

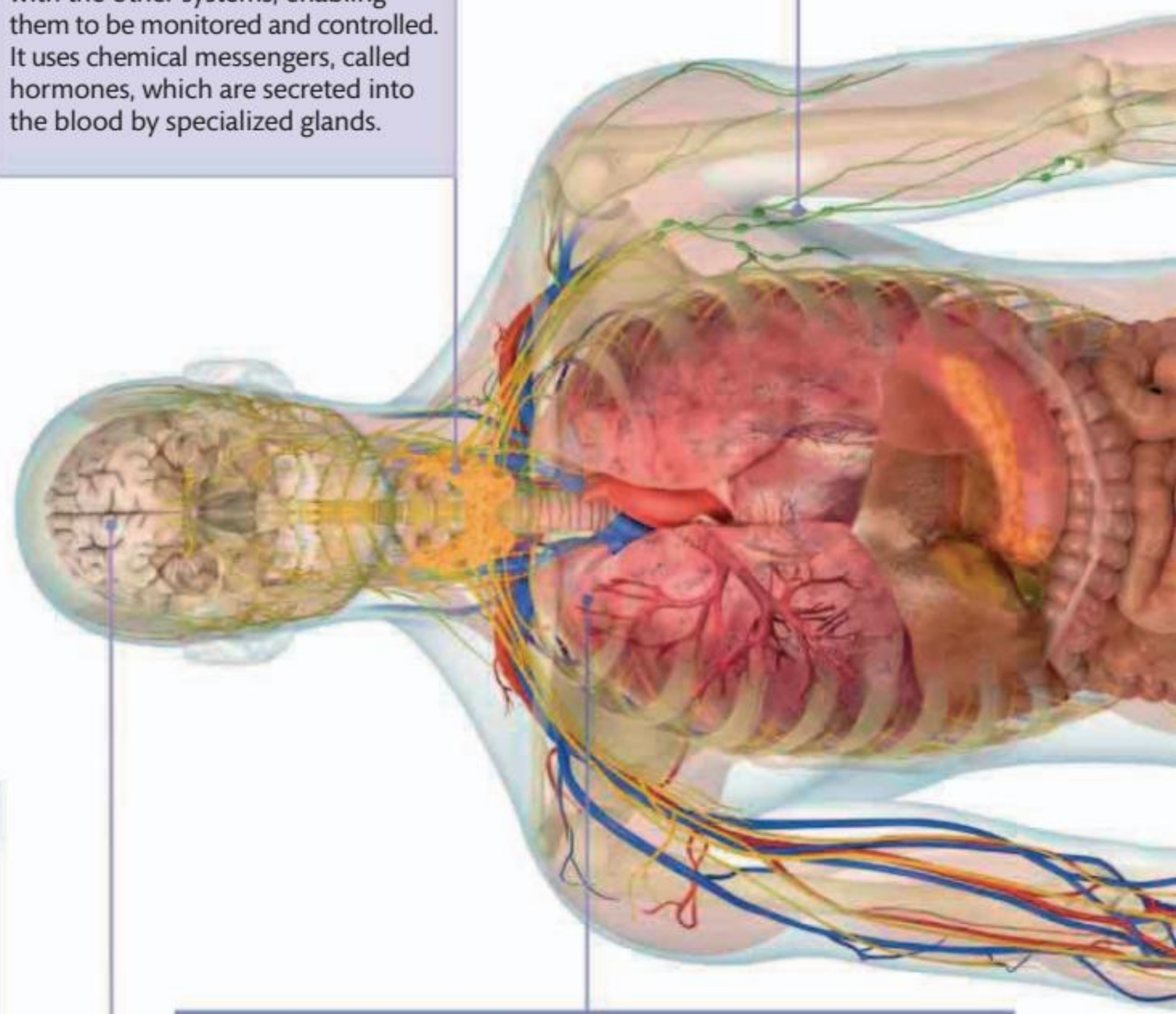


ENDOCRINE SYSTEM

The endocrine system communicates with the other systems, enabling them to be monitored and controlled. It uses chemical messengers, called hormones, which are secreted into the blood by specialized glands.

LYMPHATIC AND IMMUNE SYSTEM

The lymphatic system includes a network of vessels and nodes, which drain tissue fluid and return it to the veins. Its main functions are to maintain fluid balance within the cardiovascular system and to distribute immune cells around the body. Movement of lymphatic fluid relies on the muscles within the muscular system.



RESPIRATORY SYSTEM

Every cell in the body needs oxygen and must dispel carbon dioxide in order to function. The respiratory system ensures this by breathing air into the lungs, where the exchange of these molecules occurs between the air and blood. The cardiovascular system transports oxygen and carbon dioxide between the cells and the lungs.

NERVOUS SYSTEM

The brain, spinal cord, and nerves collect, process, and disseminate information from the body's internal and external environments. The nervous system communicates through networks of nerve cells, which connect with other systems. The brain controls and monitors all the other systems to ensure they are performing normally.

DIGESTIVE SYSTEM

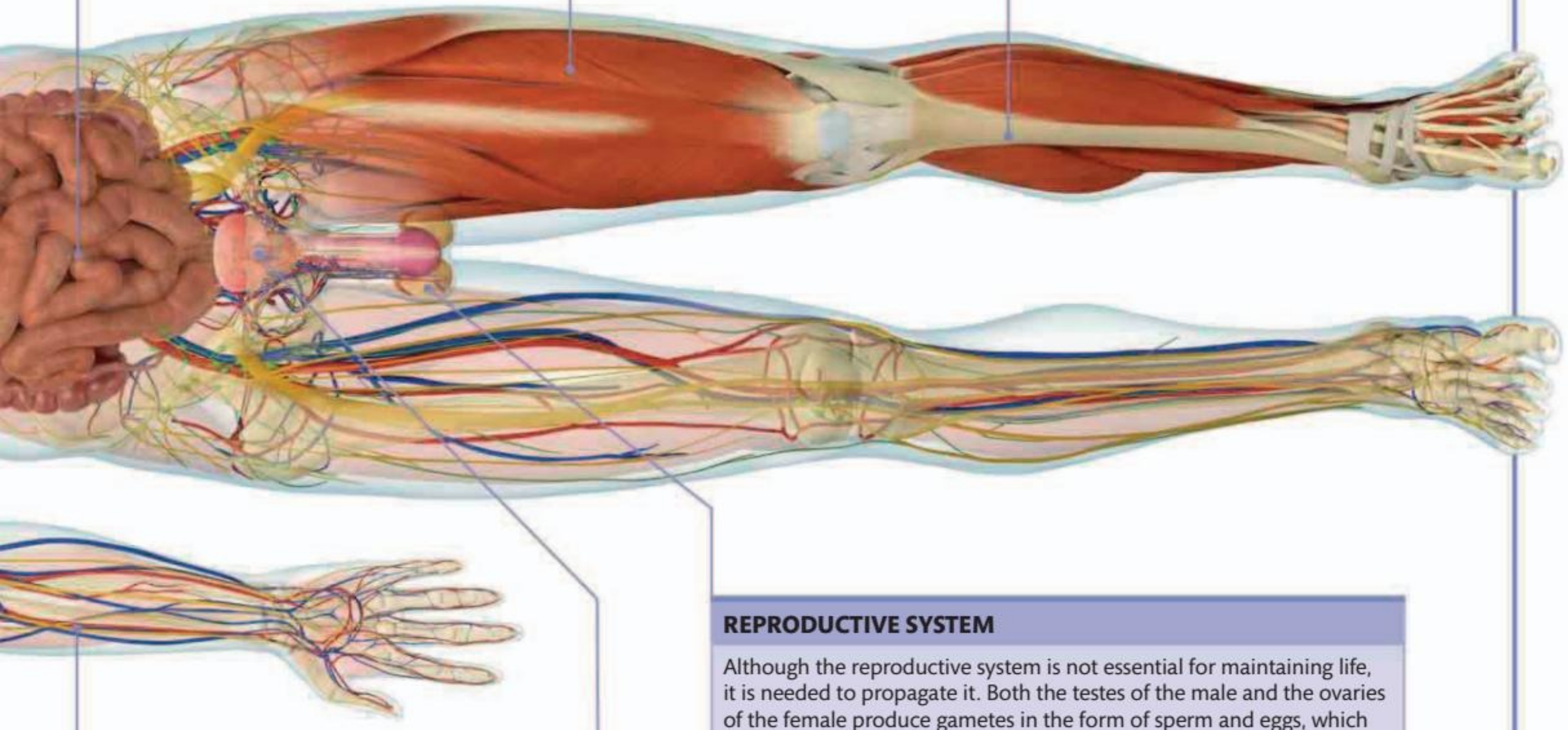
As well as oxygen, every cell needs energy in order to function. The digestive system processes and breaks down the food we eat so that a variety of nutrients can be absorbed from the intestines into the circulatory system. These are then delivered to the cells of every body system in order to provide them with energy.

MUSCULAR SYSTEM

The muscular system is made up of three types of muscle: skeletal, smooth, and cardiac. It is responsible for generating movement – both in the limbs and within the other body systems. For example, smooth muscle aids the digestive system by helping to propel food down the esophagus and through the stomach, intestines, and rectum. The respiratory system needs the thoracic muscles to contract to fill the lungs with air (see opposite).

SKELETAL SYSTEM

This system uses bones, cartilage, ligaments, and tendons to provide the body with structural support and protection. It encases much of the nervous system within a skull and vertebrae, and the vital organs of the respiratory and circulatory systems within the ribcage. The skeletal system also supports our immune and the circulatory systems by manufacturing red and white blood cells.



CARDIOVASCULAR SYSTEM

The cardiovascular system uses blood to carry oxygen from the respiratory system and nutrients from the digestive system to cells of all the body's systems. It also removes waste products from these cells. At the center of the cardiovascular system lies the muscular heart, which pumps blood through the blood vessels.

REPRODUCTIVE SYSTEM

Although the reproductive system is not essential for maintaining life, it is needed to propagate it. Both the testes of the male and the ovaries of the female produce gametes in the form of sperm and eggs, which fuse to create an embryo. The testes and ovaries also produce hormones including estrogen and testosterone, thus forming part of the endocrine system.

URINARY SYSTEM

The urinary system filters and removes many of the waste products generated by cells of the body. It does this by filtering blood through the kidneys and producing urine, which is collected in the bladder and then excreted through the urethra. The kidneys also help regulate blood pressure within the cardiovascular system by ensuring that the correct amount of water is reabsorbed by the blood.

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Anterior surface regions

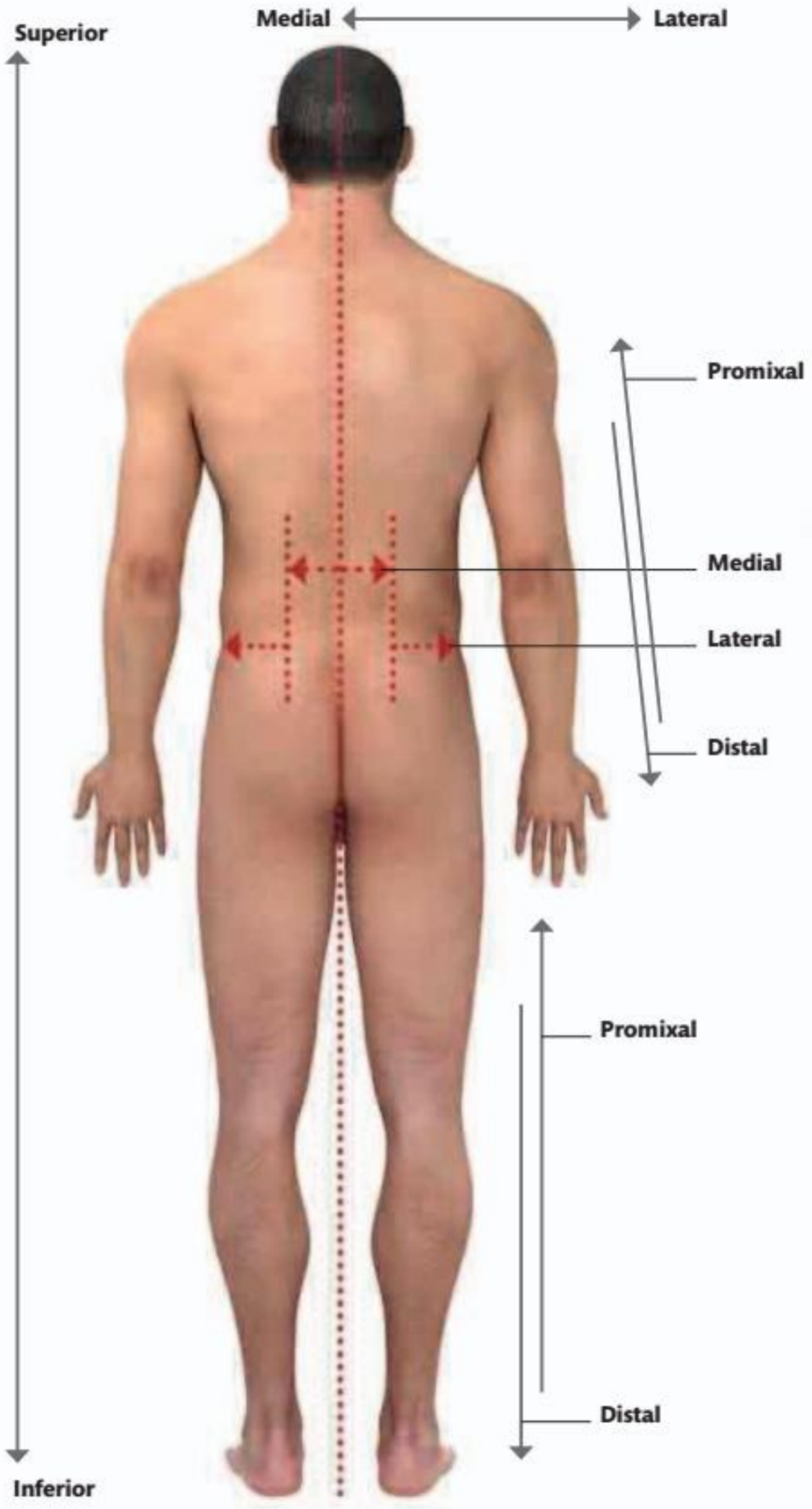
The anterior surface of the body is divided into general anatomical areas by imaginary lines drawn on the body. The location of many of these lines is defined by reference to underlying features such as muscles or bony prominences; for example, the cubital fossa is defined by reference to epicondyles of the humerus, and the pronator teres and brachioradialis muscles. Many of the regions may be divided into smaller areas. For instance, the upper part of the anterior thigh contains the femoral triangle.

Posterior surface regions

As with the anterior surface, the posterior surface can also be divided into anatomical regions. The anterior surface of the abdomen is divided by planes and mapped into nine regions—allowing doctors to describe precisely where areas of tenderness or lumps are felt on abdominal examination. The back is not divided into as many regions. This illustration shows some of the terms used for the broader regions of back of the body.

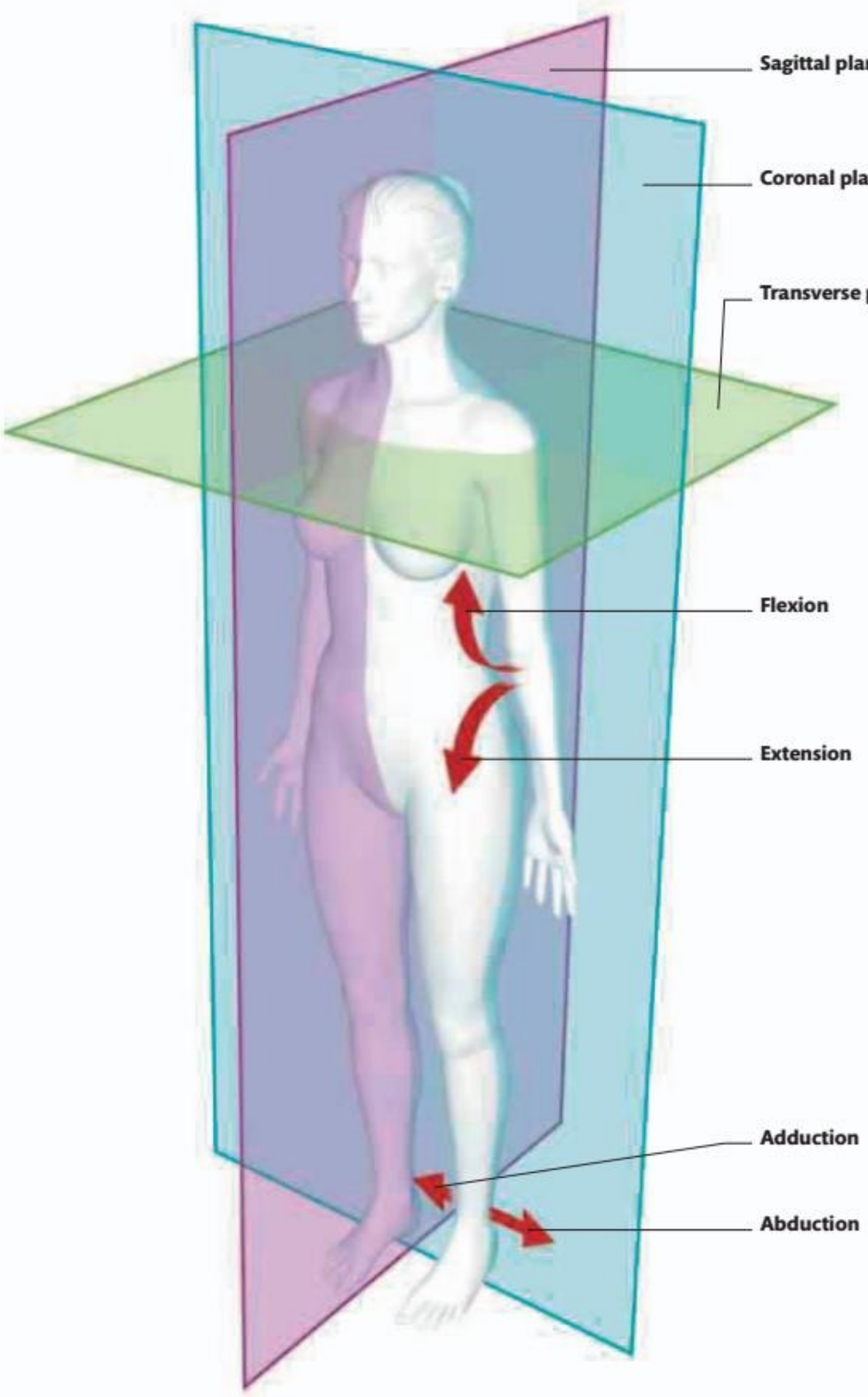
TERMINOLOGY AND PLANES

Anatomical language allows us to describe the structure of the body accurately and unambiguously. The illustrations here show the main regions of the anterior (front) and posterior (back) surfaces of the body. Sometimes it is easier to understand anatomy by dividing the body into two dimensional slices. The orientation of these planes through the body also have specific anatomical names. There are also terms to describe the relative position of structures within the body.



Directions and relative positions

As well as defining parts of the body, anatomical terminology also allows us to precisely and concisely describe the relative positions of various structures. These terms always refer back to relative positions of structures when the body is in the "anatomical position" (shown above). Medial and lateral describe positions of structures toward the midline, or toward the side of the body, respectively. Superior and inferior refer to vertical position—toward the top or bottom of the body. Proximal and distal are useful terms, describing a relative position toward the center or periphery of the body.



Anatomical terms for planes and movement

The diagram above shows the three planes—sagittal, coronal, and transverse—cutting through a body. It also illustrates some medical terms that are used to describe certain movements of body parts: flexion decreases the angle of a joint, such as the elbow, while extension increases it; adduction draws a limb closer to the sagittal plane, while abduction moves it further away from that plane.

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02 Body Systems

The human body is made up of eleven functional systems. No one system works in isolation: for example the endocrine and nervous systems work closely to keep the body regulated, while the respiratory and cardiovascular systems combine to deliver vital oxygen to cells. To build the clearest picture of how the body is put together it is, however, helpful to strip back our anatomy and consider it system by system. This chapter gives an overview of the basic structure of each system before looking at each region in detail.

022 Skin, hair, and nail
024 Skeletal system
068 Muscular system
110 Nervous system
146 Respiratory system
154 Cardiovascular system
180 Lymphatic and immune system
192 Digestive system
204 Urinary system
208 Reproductive system
216 Endocrine system

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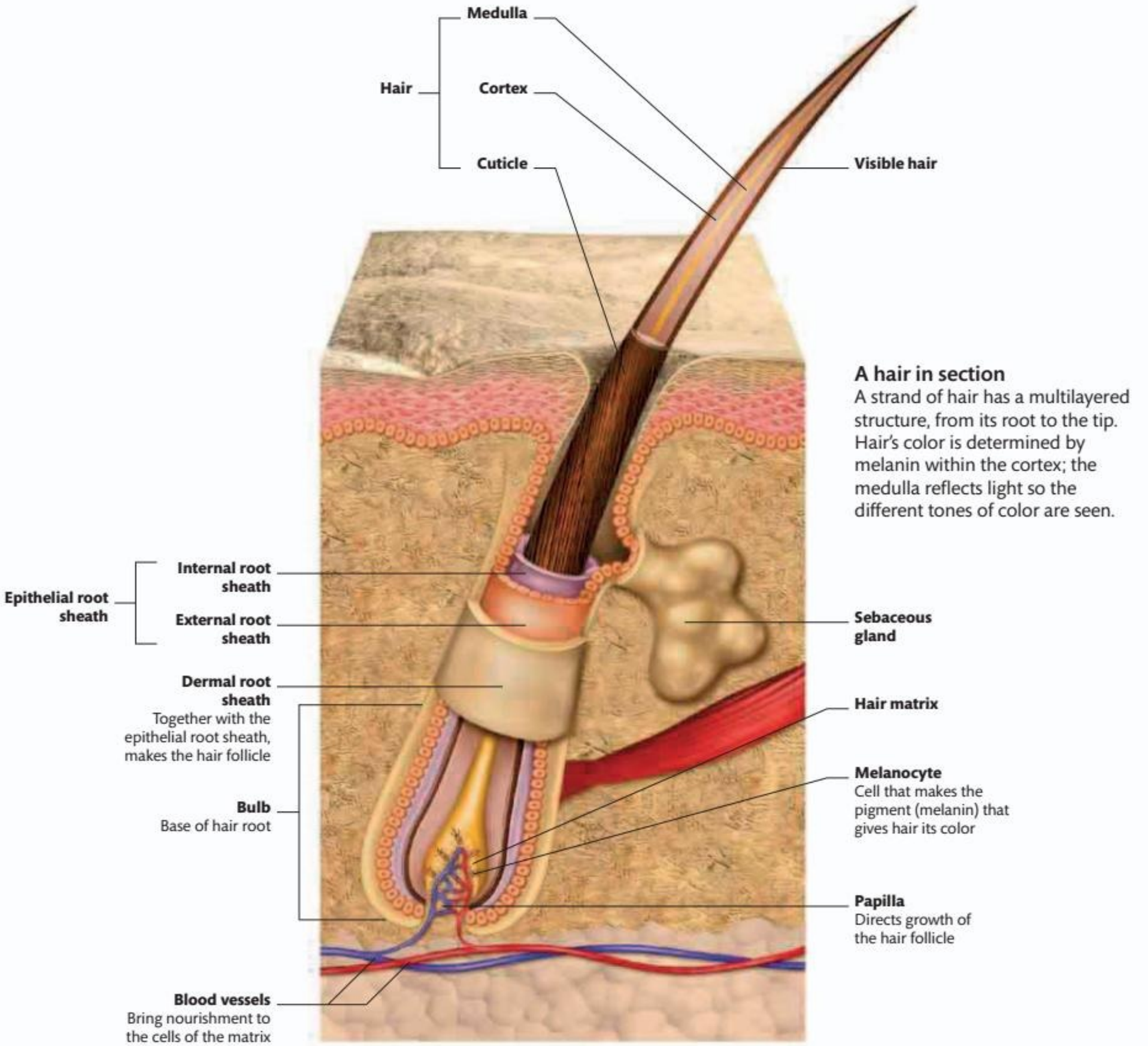
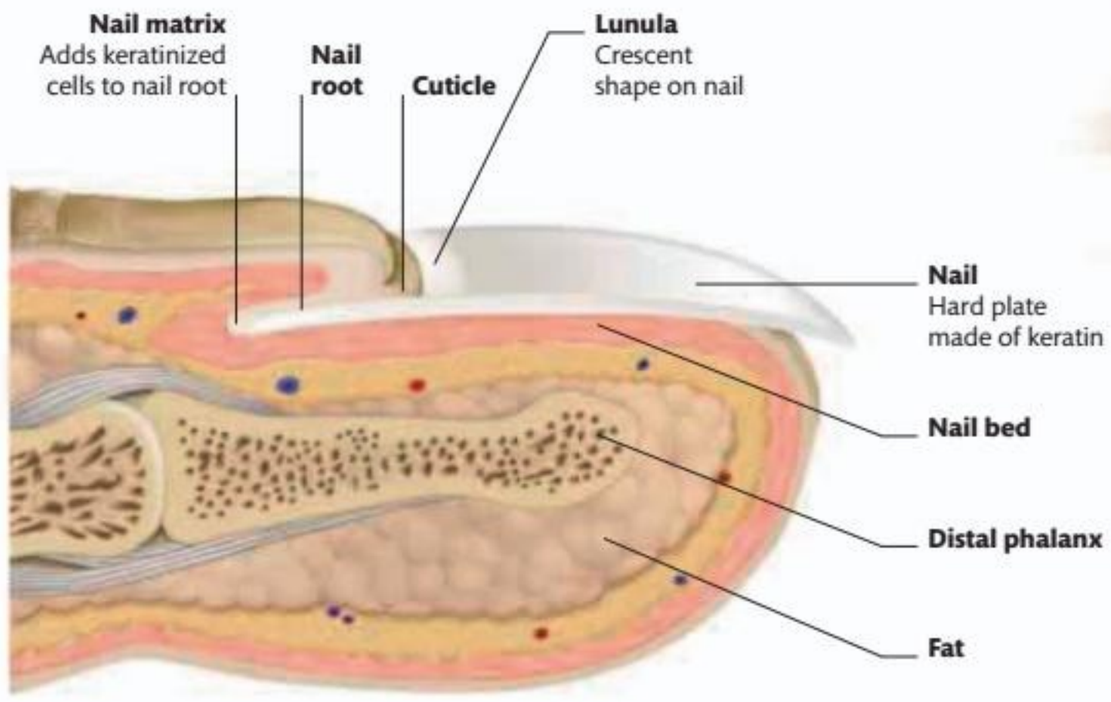


A hair in section
A strand of hair has a multilayered structure, from its root to the tip. Hair's color is determined by melanin within the cortex; the medulla reflects light so the different tones of color are seen.

SECTION THROUGH A HAIR

SKIN, HAIR, AND NAIL

The skin is our largest organ, weighing about 9lb (4kg) and covering an area of about 21 square feet (2 square meters). It forms a tough, waterproof layer, which protects us from the elements. However, it offers much more than protection: the skin lets us appreciate the texture and temperature of our environment; it regulates body temperature; it allows excretion in sweat; communication through blushing; gripping thanks to ridges on our fingertips, and vitamin D production in sunlight. Thick head hairs and fine body hairs help to keep us warm and dry. All visible hair is in fact dead; hairs are only alive at their root. Constantly growing and self-repairing, nails protect fingers and toes but also enhance their sensitivity.

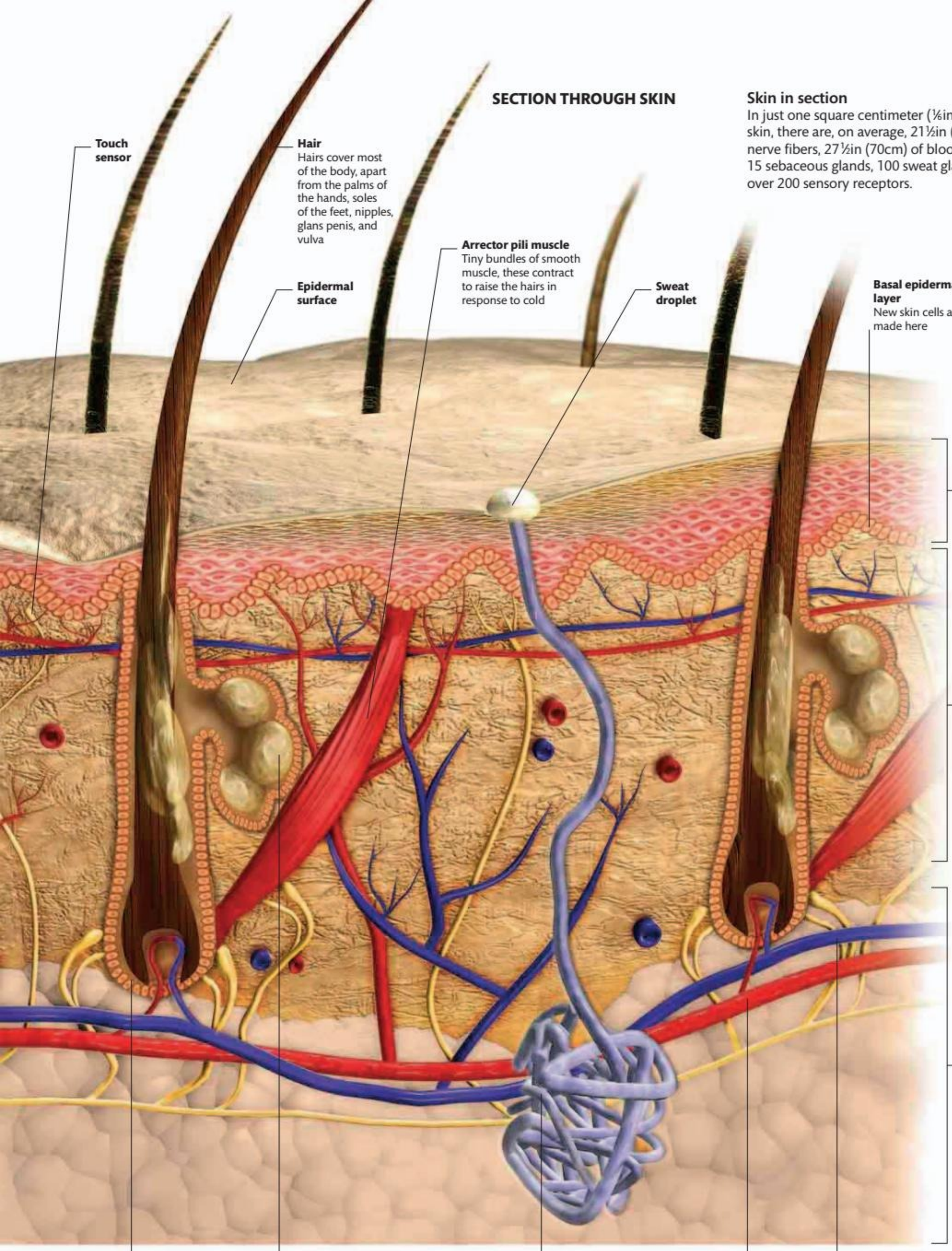


SECTION THROUGH A NAIL

SECTION THROUGH SKIN

Skin in section

In just one square centimeter (⅛in²) of the skin, there are, on average, 21½in (55cm) of nerve fibers, 27½in (70cm) of blood vessels, 15 sebaceous glands, 100 sweat glands, and over 200 sensory receptors.



Touch sensor

Hair
Hairs cover most of the body, apart from the palms of the hands, soles of the feet, nipples, glans penis, and vulva

Epidermal surface

Arrector pili muscle
Tiny bundles of smooth muscle, these contract to raise the hairs in response to cold

Sweat droplet

Basal epidermal layer
New skin cells are made here

Epidermis
Outermost layer of the skin, comprising constantly renewing layers of cells called keratinocytes

Dermis
Inner layer, composed of dense connective tissue, containing the nerves and blood vessels that supply the skin

Hypodermis
Layer of loose connective tissue under the skin; also known as superficial fascia

Hair follicle
Cuplike structure in the dermis or hypodermis forms a socket for a hair

Sebaceous gland
Secretes sebum into the hair follicle; this oily secretion helps to waterproof the skin and keep it supple, and also has an antibacterial effect

Sweat gland
Coiled tube extend upward from the dermis to open at a pore on the surface of the epidermis

Arteriole

Venule

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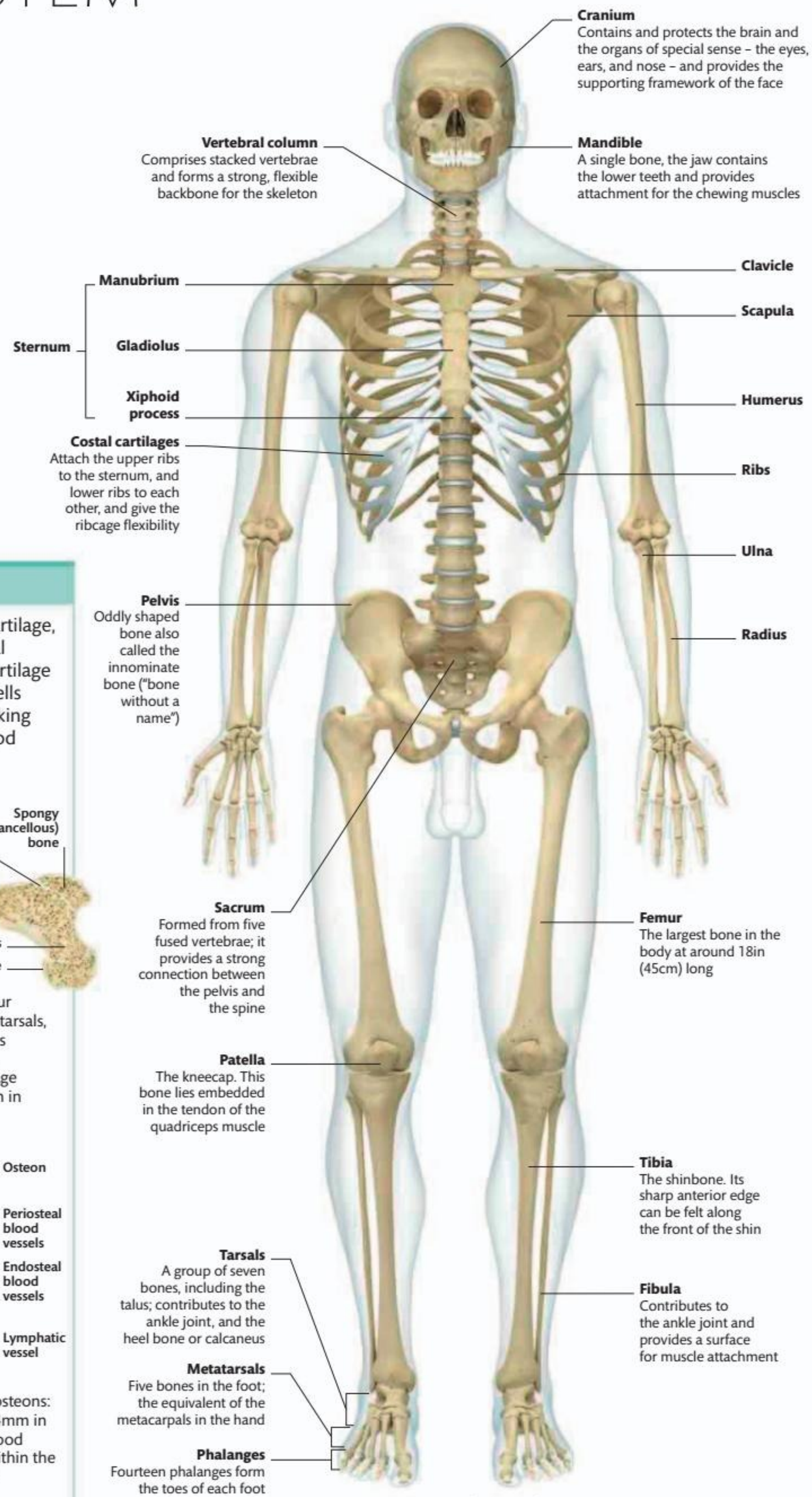
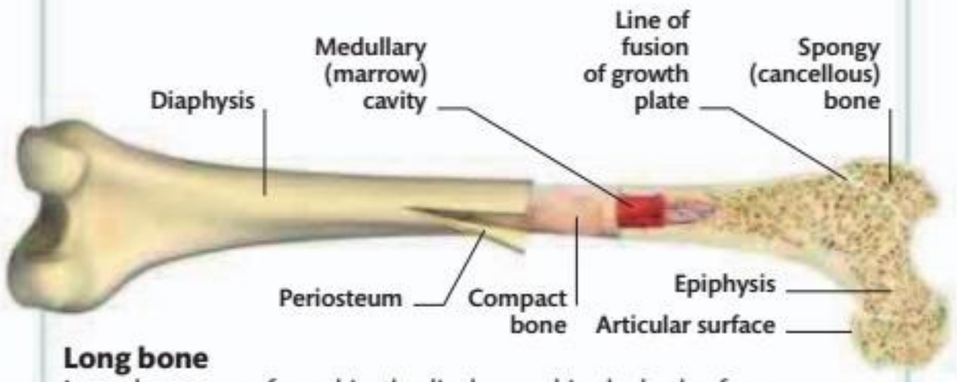
SKELETAL SYSTEM
OVERVIEW

The human skeleton gives the body its shape, supports the weight of all our other tissues, provides attachment for muscles, and forms a system of linked levers that the muscles can move. It also protects delicate organs and tissues, such as the brain within the skull, the spinal cord within the arches of the vertebrae, and the heart and lungs within the ribcage. The skeletal system differs between the sexes. This is most obvious in the pelvis, which is usually wider in a woman than in a man. The skull also varies, with men having a larger brow and more prominent areas for muscle attachment on the back of the head. The entire skeleton tends to be larger and more robust in a man.

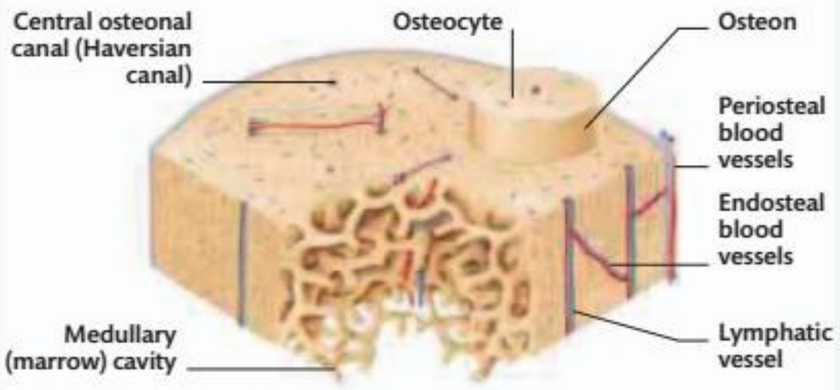


BONE STRUCTURE

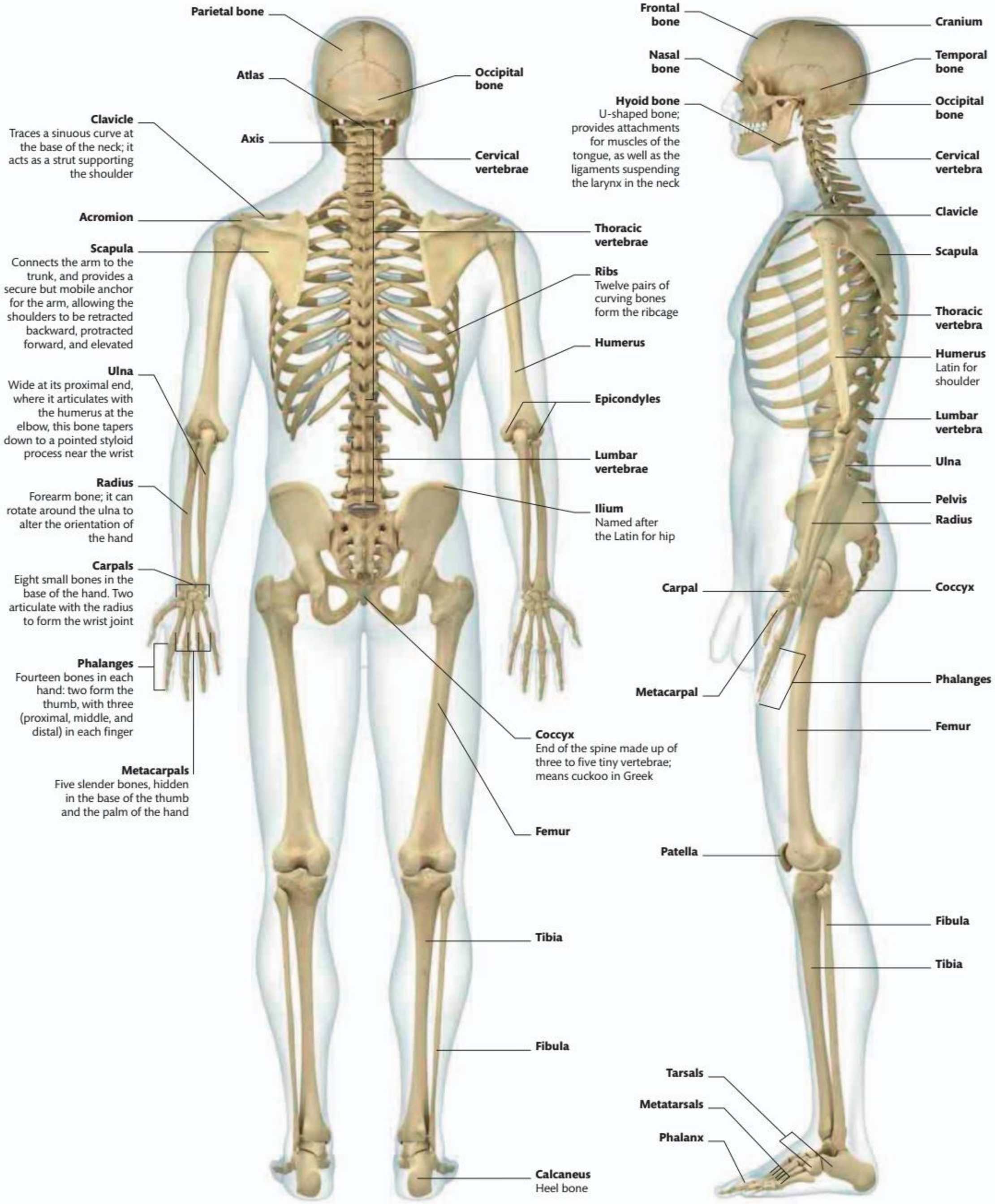
Most of the human skeleton develops first as cartilage, which is later replaced by bone throughout fetal development and childhood. Both bone and cartilage are connective tissues. Bone tissue consists of cells that are embedded in a mineralized matrix, making it extremely hard and strong. Bone is full of blood vessels and repairs easily.



Long bone
Long bones are found in the limbs, and include the femur (shown above), humerus, radius, ulna, tibia, fibula, metatarsals, metacarpals, and phalanges. A long bone has flared ends (epiphyses), which narrow to form a neck (metaphysis), tapering down into a cylindrical shaft (diaphysis). Cartilage growth plates near the ends of bones allow rapid growth in childhood, but disappear by adulthood.



Compact bone
Also called cortical bone, compact bone is made up of osteons: concentric cylinders of bone tissue, each around 0.1–0.4mm in diameter, with a central vascular canal. Bone is full of blood vessels: those in the osteons connect to blood vessels within the medullary cavity of the bone as well as to vessels in the periosteum on the outside.



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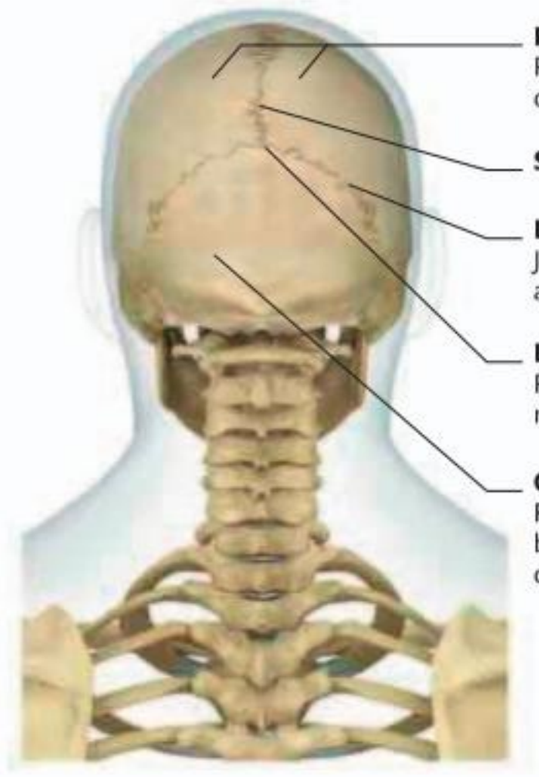
HEAD AND NECK

The skull comprises the cranium and mandible. It houses and protects the brain and the eyes, ears, nose, and mouth. It encloses the first parts of the airway and of the alimentary canal, and provides attachment for the muscles of the head and neck. The cranium itself comprises more than 20 bones that meet each other at fibrous joints called sutures. In addition to the main bones labeled on these pages, there are sometimes extra bones along the sutures. In a young adult skull, the sutures are visible as tortuous lines between the cranial bones; they gradually fuse with age. The mandible of a newborn baby is in two halves, with a fibrous joint in the middle. The joint fuses during early infancy, so that the mandible becomes a single bone.



Parietal bones
Paired bones forming most of the roof and sides of skull

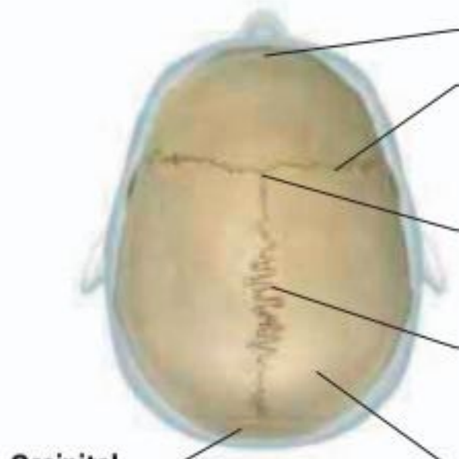
Sagittal suture

Lambdoid suture
Joint between occipital and parietal bones

Lambda
Point where the sagittal suture meets the lambdoid suture

Occipital bone
Forms lower part of back of skull, and back of cranial base

BACK



Frontal bone

Coronal suture
Where the frontal and parietal bones meet; crosses the skull's highest part (the crown)

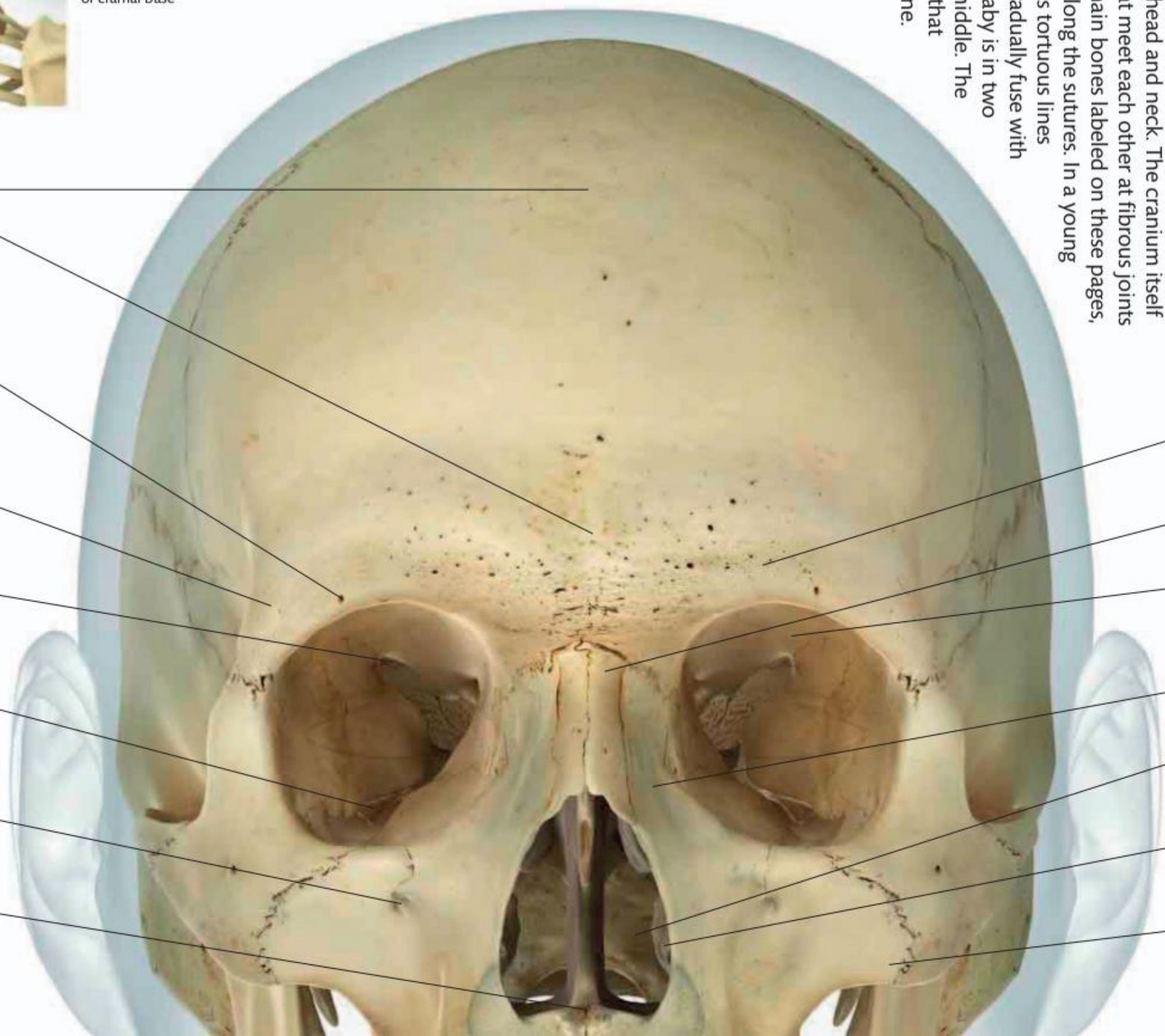
Bregma
Where the sagittal and coronal sutures meet

Sagittal suture
Joint on the midline (sagittal plane) where parietal bones meet

Occipital bone

Parietal bone
From the Latin for wall

TOP



Frontal bone

Glabella
Area between the two superciliary arches; glabella comes from the Latin for smooth, and refers to the bare area between the eyebrows

Supraorbital foramen
The supraorbital nerve passes through this hole to supply sensation to the forehead

Zygomatic process of frontal bone
Runs down to join the frontal process of the zygomatic bone

Superior orbital fissure
Gap between the sphenoid bone's greater and lesser wings, opening into the orbit

Inferior orbital fissure
Gap between the maxilla and the greater wing of the sphenoid bone, opening into the back of the orbit

Infraorbital foramen
Hole for infraorbital branch of maxillary nerve to supply sensation to the cheek

Nasal crest
Where the two maxillae meet; the vomer (part of the septum) sits on the crest

Superciliary arch
Also called the supraorbital ridge, or brow ridge; from the Latin for eyebrow

Nasal bone
Two small bones form the bony bridge of the nose

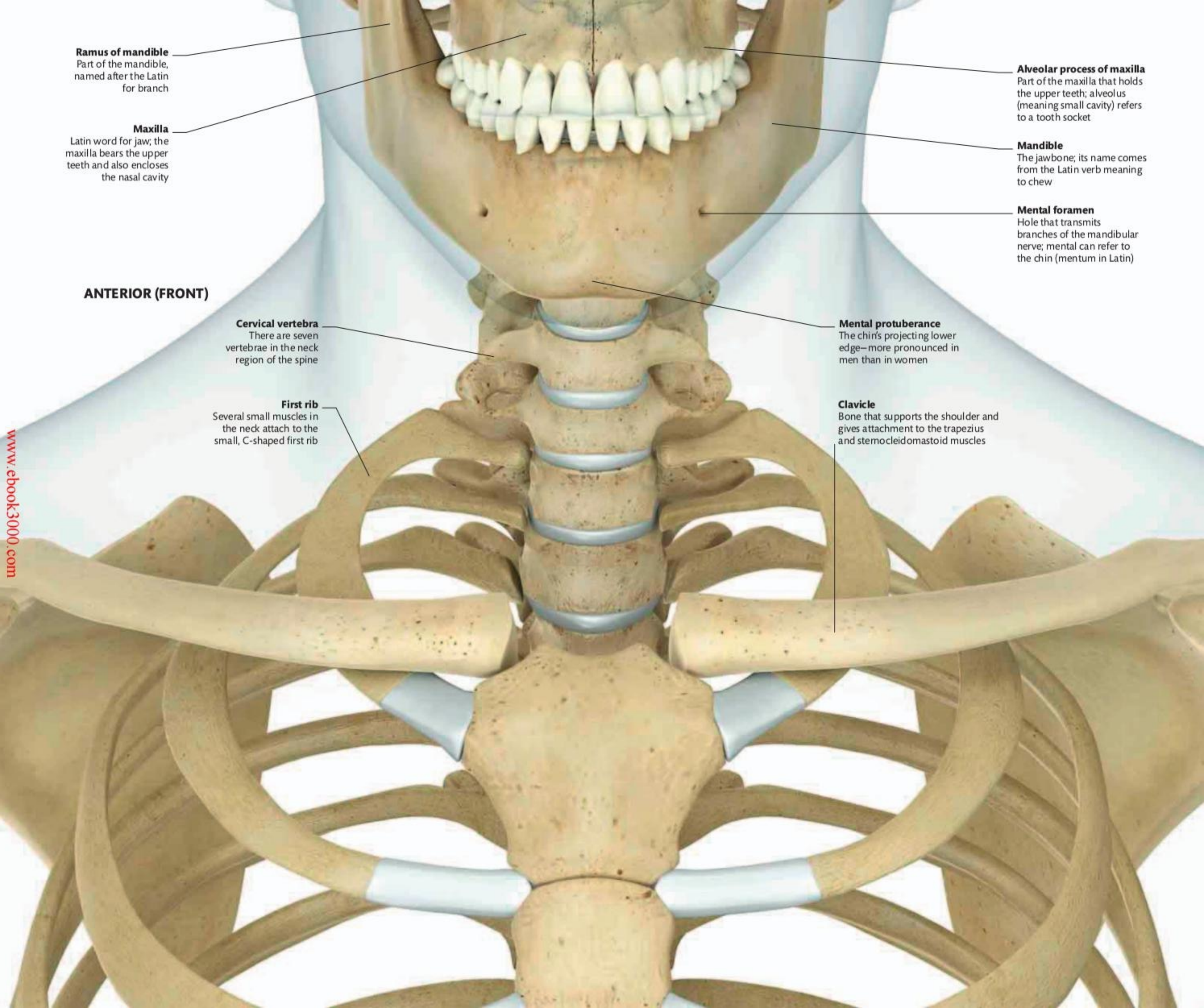
Orbit
Technical term for the eye-socket, from the Latin for wheel track

Frontal process of maxilla
Rises up on the medial (inner) side of the orbit

Piriform aperture
Pear-shaped (piriform) opening; also called the anterior nasal aperture

Inferior nasal concha
Lowest of the three curled protrusions on the lateral wall of the nasal cavity

Zygomatic process of maxilla
Part of the maxilla that projects laterally (to the side)



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HEAD AND NECK

The cervical spine includes seven vertebrae, the top two of which have specific names. The first vertebra, which supports the skull, is called the atlas, after the Greek god who carried the sky on his shoulders. Nodding movements of the head occur at the joint between the atlas and the skull. The second cervical vertebra is the axis, from the Greek word for axle, so-called because when you shake your head from side to side, the atlas rotates on the axis. In this side view, we can also see more of the bones that make up the cranium, as well as the temporomandibular (jaw) joint between the mandible and the skull. The hyoid bone is also visible. This small bone is a very important anchor for the muscles that form the tongue and the floor of the mouth, as well as muscles that attach to the larynx and pharynx.

Tympanic part of temporal bone
Forms floor of the external acoustic meatus, at the inner end of which lies the tympanic membrane, or eardrum

Parietal bone

Squamosal suture
The articulation between squamous part of temporal bone and parietal bone

Parietomastoid suture
Here the parietal bone meets the posterior, mastoid part of the temporal bone

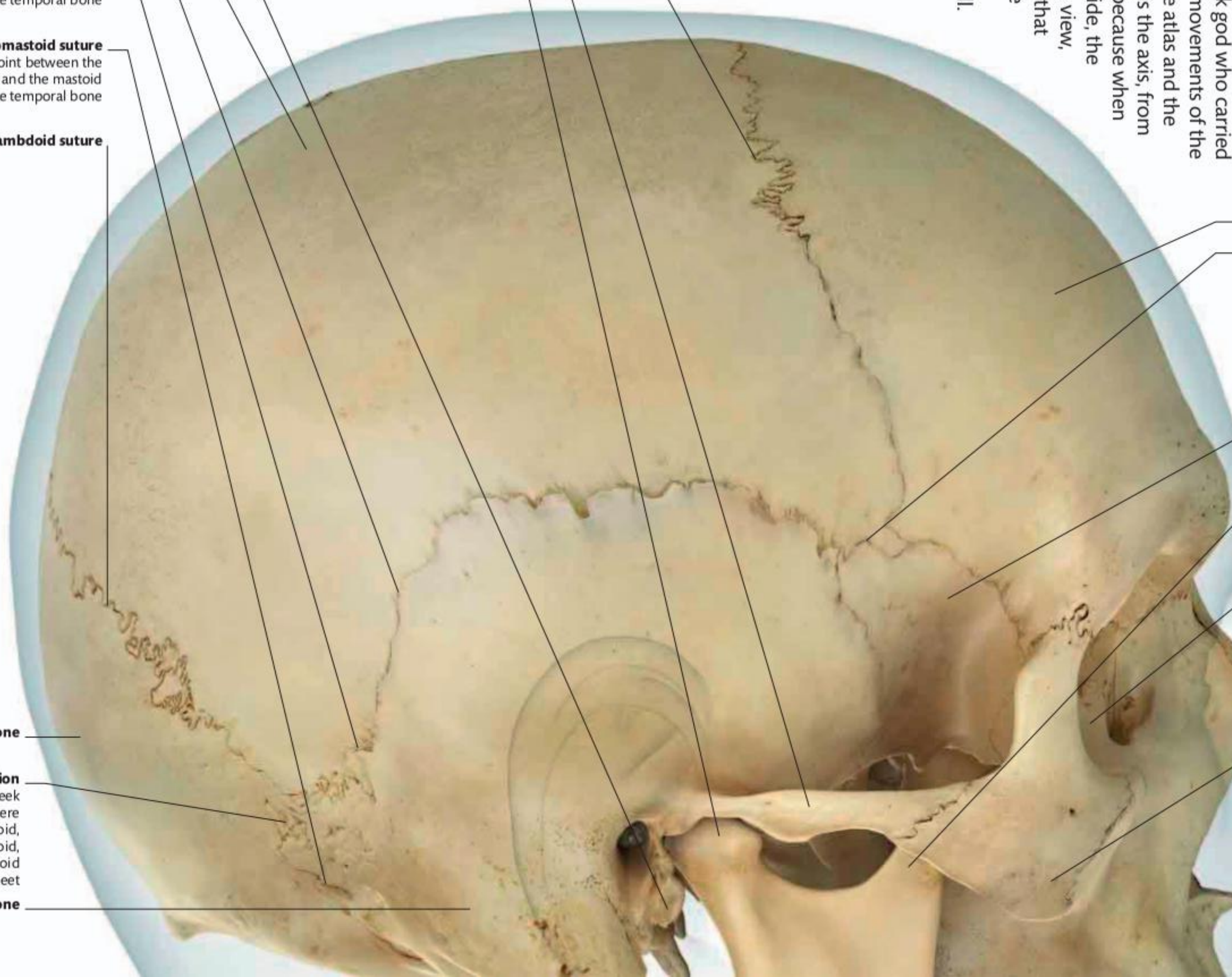
Occipitomastoid suture
Fibrous joint between the occipital bone and the mastoid part of the temporal bone

Lambdoid suture

Coronal suture

Zygomatic arch
Formed by the zygomatic process of the temporal bone projecting forward to meet the temporal process of the zygomatic bone

Condyle
Condylar process projects upwards to end as the condyle, or head of the mandible, which articulates with the cranium at the temporomandibular (jaw) joint



Occipital bone

Asterion
From the Greek for star; it is where the lambdoid, occipitomastoid, and parietomastoid sutures meet

Temporal bone

Frontal bone

Pterion
Area on side of skull where the frontal, parietal, temporal, and sphenoid bones come close together; it is a key surgical landmark as the middle meningeal artery runs up inside the skull at this point and may be damaged by a fracture to this area

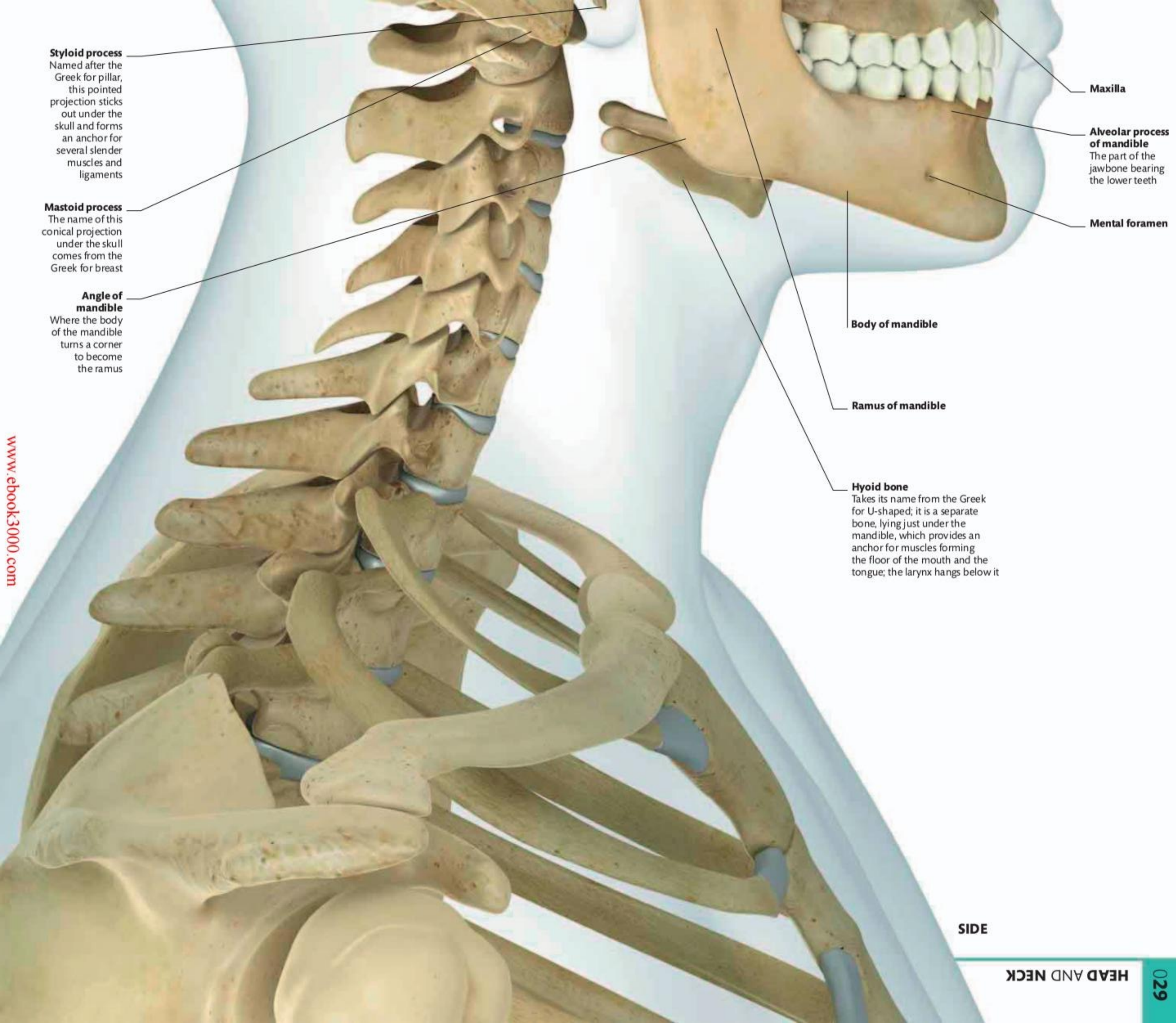
Greater wing of sphenoid bone

Coronoid process of mandible
This is where the temporalis muscle attaches to the jawbone

Lacrimal bone
Tears drain from the surface of the eye into the nasolacrimal duct, which lies in a groove in this bone

Nasal bone

Zygomatic bone
From the Greek for yoke; it forms a link between the bones of the face and the side of the skull



SIDE

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HEAD AND NECK

The most striking features of the skull viewed from these angles are the holes in it. In the middle, there is one large hole—the foramen magnum—through which the brain stem emerges to become the spinal cord. But there are also many smaller holes, most of them paired. Through these holes, the cranial nerves from the brain escape to supply the muscles, skin, and mucosa, and the glands of the head and neck. Blood vessels also pass through some holes, on their way to and from the brain. At the front, we can also see the upper teeth sitting in their sockets in the maxillae, and the bony, hard palate.

Foramen magnum
Latin for large hole; the brain stem emerges here

Internal occipital protuberance
Located near the confluence of the sinuses, where the superior sagittal, transverse, and straight sinuses (the large veins in the dura mater) meet

Hypoglossal canal
The hypoglossal nerve, supplying the tongue muscles, exits here

Basiocciput
Part of the occipital bone, in front of the foramen magnum, which fuses with the body of the sphenoid bone

Internal acoustic meatus
The facial and vestibulocochlear nerves pass through this hole

Foramen spinosum
Entry point of the middle meningeal artery, which supplies the dura mater and the bones of the skull

Lesser wing of sphenoid bone

Optic canal

Cribriform plate of ethmoid
Area of the ethmoid bone pierced by holes, through which the olfactory nerves pass. Cribriform is Latin for sievelike; ethmoid, taken from Greek, also means sievelike

Foramen caecum
Named after the Latin for blind, this is a blind-ended pit

Mastoid foramen
An emissary (valveless) vein passes out through this hole

Jugular foramen
The internal jugular vein and the glossopharyngeal, vagus, and accessory nerves emerge from this hole

Petrous part of temporal bone

Foramen lacerum

Foramen ovale

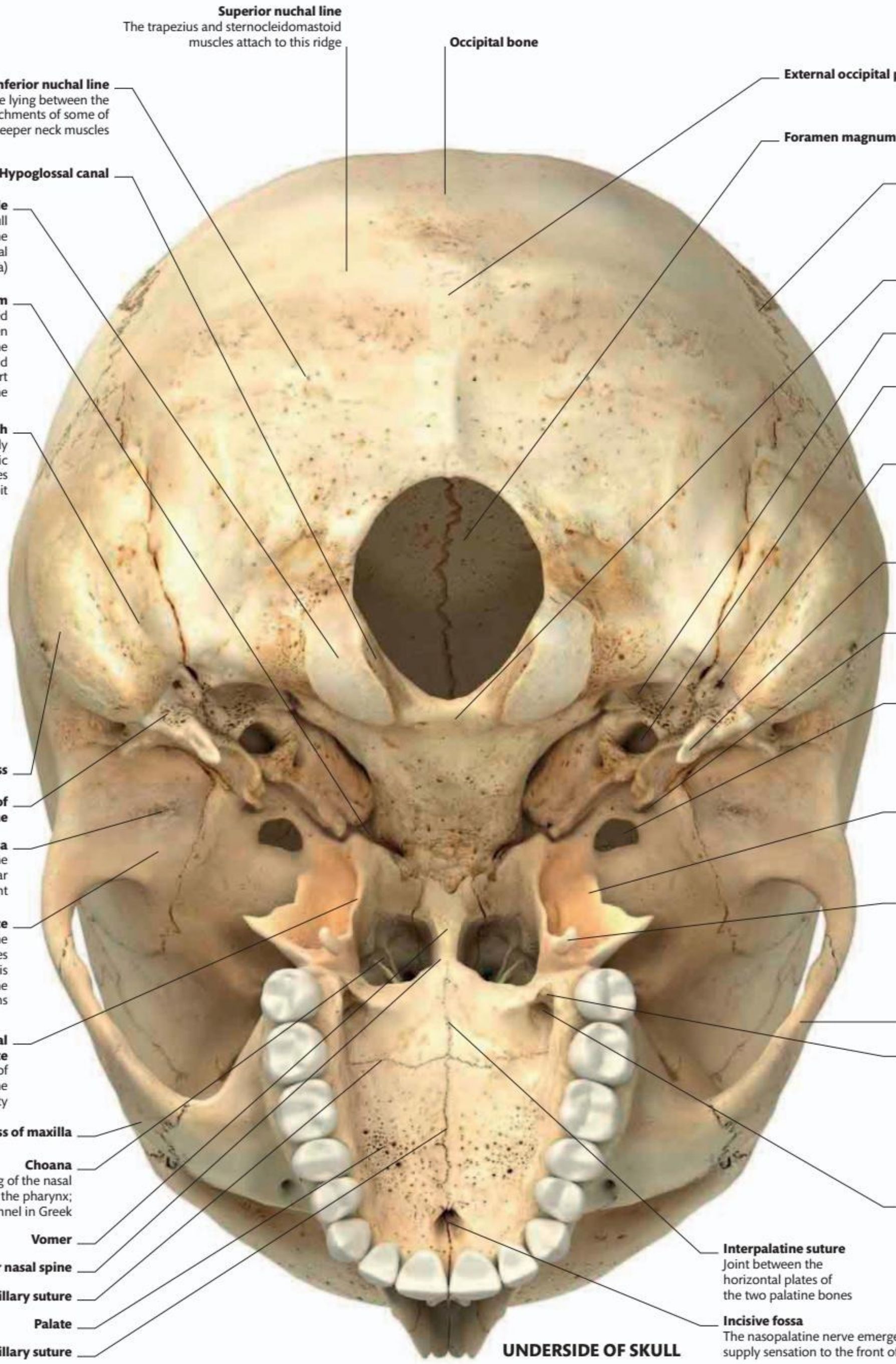
Pituitary fossa

Foramen rotundum
The maxillary division of the trigeminal nerve passes through this round hole

Orbital part of frontal bone
Part of the frontal bone that forms the roof of the orbit, and also the floor at the front of the cranial cavity

Crista galli
Vertical crest on the ethmoid bone that takes its name from the Latin for cock's comb; it provides attachment for the falx cerebri—the membrane between the two cerebral hemispheres

INTERNAL SURFACE OF BASE OF SKULL



Superior nuchal line
The trapezius and sternocleidomastoid muscles attach to this ridge

Occipital bone

Inferior nuchal line
Slight ridge lying between the attachments of some of the deeper neck muscles

External occipital protuberance

Foramen magnum

Hypoglossal canal

Lambdoid suture

Occipital condyle
Where the skull articulates with the atlas (first cervical vertebra)

Pharyngeal tubercle

Foramen lacerum
Fibrocartilage-filled hole between the body of the phenoid bone and the petrous part of the temporal bone

Jugular foramen

Carotid canal
The internal carotid artery enters here

Digastric notch
The posterior belly of the digastric muscle attaches to this pit

Stylomastoid foramen
The facial nerve emerges through this hole

Styloid process

Foramen spinosum

Mastoid process

Foramen ovale
The mandibular division of the trigeminal nerve goes through this hole

Tympanic part of temporal bone

Lateral pterygoid plate
An anchor point for jaw muscles

Mandibular fossa
Socket for the temporomandibular (jaw) joint

Pterygoid hamulus
The word hamulus means small hook in Latin

Articular eminence
The condyle of the mandible moves forward onto this area as the jaw opens

Zygomatic arch

Medial pterygoid plate
Forms the back of the side wall of the nasal cavity

Lesser palatine foramina
The lesser palatine arteries and nerves pass through this hole and run backward to supply the soft palate

Zygomatic process of maxilla

Greater palatine foramen
This hole transmits the greater palatine artery and nerve, which supply the hard palate

Choana
Opening of the nasal cavity into the pharynx; from funnel in Greek

Interpalatine suture
Joint between the horizontal plates of the two palatine bones

Vomer

Posterior nasal spine

Palatomaxillary suture

Incisive fossa
The nasopalatine nerve emerges here to supply sensation to the front of the palate

Palate

Intermaxillary suture

UNDERSIDE OF SKULL

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HEAD AND NECK

This section—right through the middle of the skull—lets us in on some secrets. We can clearly appreciate the size of the cranial cavity, which is almost completely filled by the brain, with just a small gap for membranes, fluid, and blood vessels. Some of those blood vessels leave deep grooves on the inner surface of the skull: we can trace the course of the large venous sinuses and the branches of the middle meningeal artery. We can also see that the skull bones are not solid, but contain trabecular bone (or diploe), which itself contains red marrow. Some skull bones also contain air spaces, like the sphenoidal sinus visible here. We can also appreciate the large size of the nasal cavity, hidden away inside the skull.

Frontal bone
Forms the anterior cranial fossa, where the frontal lobes of the brain lie, inside the skull

Frontal sinus
One of the paranasal air sinuses that drain into the nasal cavity, this is an air space within the frontal bone

Nasal bone

Pituitary fossa
Fossa is the Latin word for ditch; the pituitary gland occupies this small cavity on the upper surface of the sphenoid bone

Sphenoidal sinus
Another paranasal air sinus; it lies within the body of the sphenoid bone

Superior nasal concha
Part of the ethmoid bone, which forms the roof and upper side walls of the nasal cavity

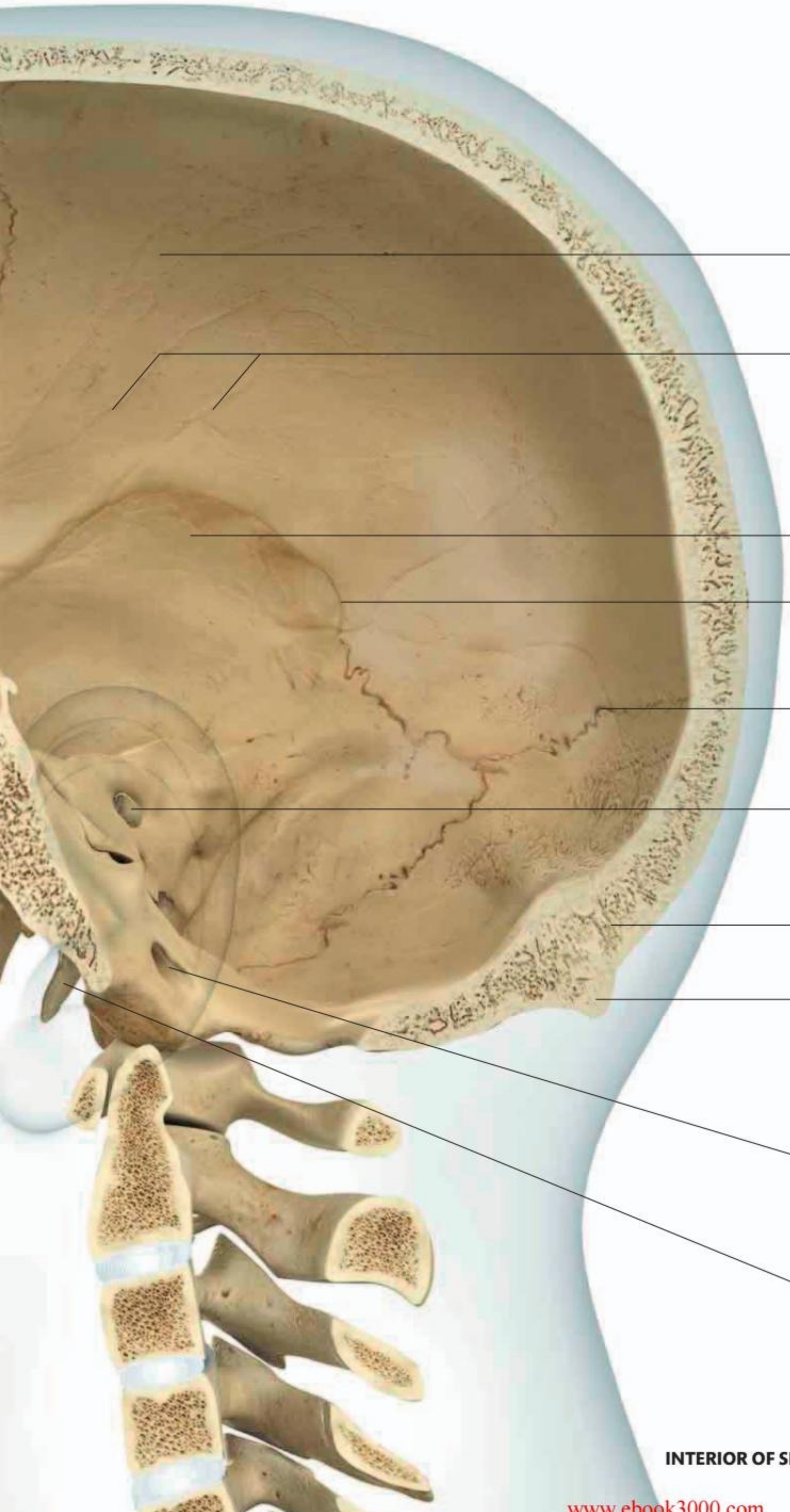
Middle nasal concha
Like the superior nasal concha, this is also part of the ethmoid bone

Inferior nasal concha
A separate bone, attached to the inner surface of the maxilla; the conchae increase the surface area of the nasal cavity

Anterior nasal crest

Palatine bone
Joins to the maxilla and forms the back of the hard palate

Pterygoid process
Sticking down from the greater wing of the sphenoid bone, this process flanks the back of the nasal cavity and provides attachment for muscles of the palate and jaw



Parietal bone

Grooves for arteries
Meningeal arteries branch on the inside of the skull and leave grooves on the bones

Squamous part of the temporal bone

Squamosal suture

Lambdoid suture

Internal acoustic meatus
Hole in petrous part of the temporal bone that transmits both the facial and vestibulocochlear nerves

Occipital bone

External occipital protuberance
Projection from occipital bone that gives attachment to the nuchal ligament of the neck; much more pronounced in men than in women

Hypoglossal canal
Hole through occipital bone, in the cranial base, which transmits the hypoglossal nerve supplying the tongue muscles

Styloid process

INTERIOR OF SKULL

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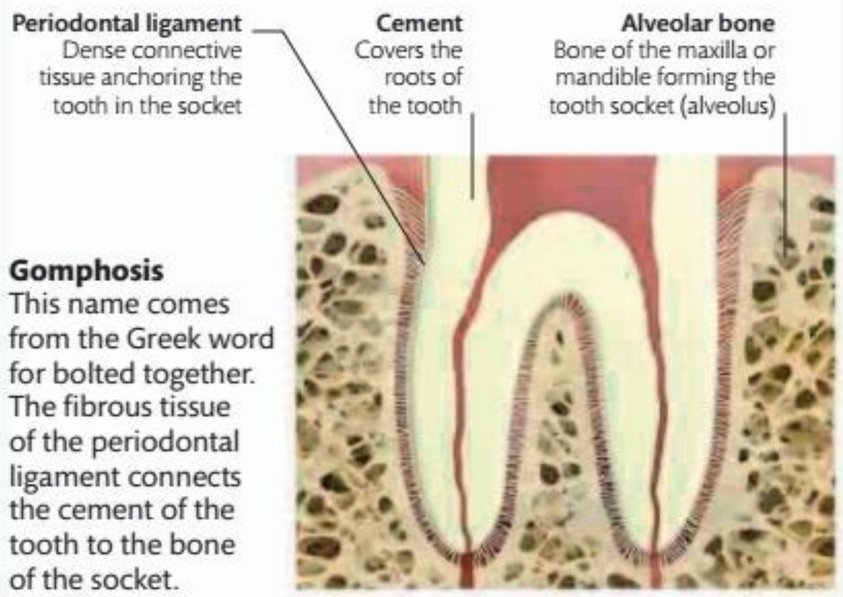
HEAD AND NECK

In this view of the skull, we can clearly see that it is not one single bone, and we can also see how the various cranial bones fit together to produce the shape we are more familiar with. The butterfly-shaped sphenoid bone is right in the middle of the action—it forms part of the skull base, the orbits, and the side walls of the skull, and it articulates with many of the other bones of the skull. The temporal bones also form part of the skull's base and side walls. The extremely dense petrous parts of the temporal bones contain and protect the delicate workings of the ear, including the tiny ossicles (malleus, incus, and stapes) that transmit vibrations from the eardrum to the inner ear.

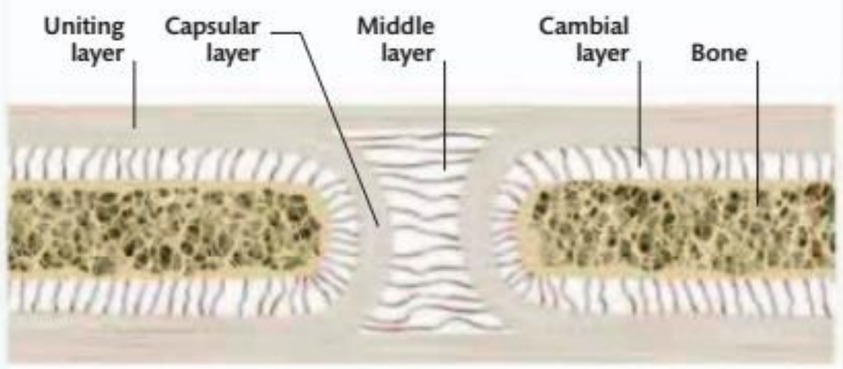
FIBROUS JOINTS

In places, the connective tissue between developing bones solidifies to create fibrous joints. Linked by microscopic fibers of collagen, these fixed joints anchor the edges of adjacent bones, or bone and tooth, so that they are locked together. Such joints include the sutures of the skull, the teeth sockets (gomphoses), and the lower joint between the tibia and fibula.



TOOTH

Gomphosis
This name comes from the Greek word for bolted together. The fibrous tissue of the periodontal ligament connects the cement of the tooth to the bone of the socket.



SKULL

Suture
These joints exist between flat bones of the skull. They are flexible in the skull of a newborn baby, and allow growth of the skull throughout childhood. The sutures in the adult skull are interlocking, practically immovable joints, and eventually fuse completely in later adulthood.

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Sphenoid bone

Petrous part of temporal bone

Orbital plate of ethmoid bone

Nasal bone

Lacrimal bone

Zygomatic process

Zygomatic bone

Orbital surface of maxilla

Temporal bone
Articulates with the parietal, sphenoid, and occipital bones and contains the ear apparatus, including the ossicles

Mastoid process

Vomer

Maxilla
Articulates with the opposite maxilla in the midline, with the nasal, frontal, and lacrimal bones above, and the sphenoid, ethmoid, and palatine bones

Zygomatic bone
This roughly triangular bone connects the frontal bone, maxilla, and temporal bone

Ramus of mandible

Alveolar process of maxilla
Projects down from the maxilla and forms the sockets for the upper teeth

Frontal bone

Angle of mandible
The masseter muscle attaches down to this angle, which tends to be slightly flared outward in men

Alveolar process of mandible
Projects up from the mandible and forms the sockets for the lower teeth

Nasal bones
Two bones, attaching to the frontal bone above and the maxillae to the side, form the bridge of the nose

Maxilla

Occipital bone
Forms the lower part of the back of the skull

Body of mandible
The mandible develops as two separate bones, which fuse in infancy

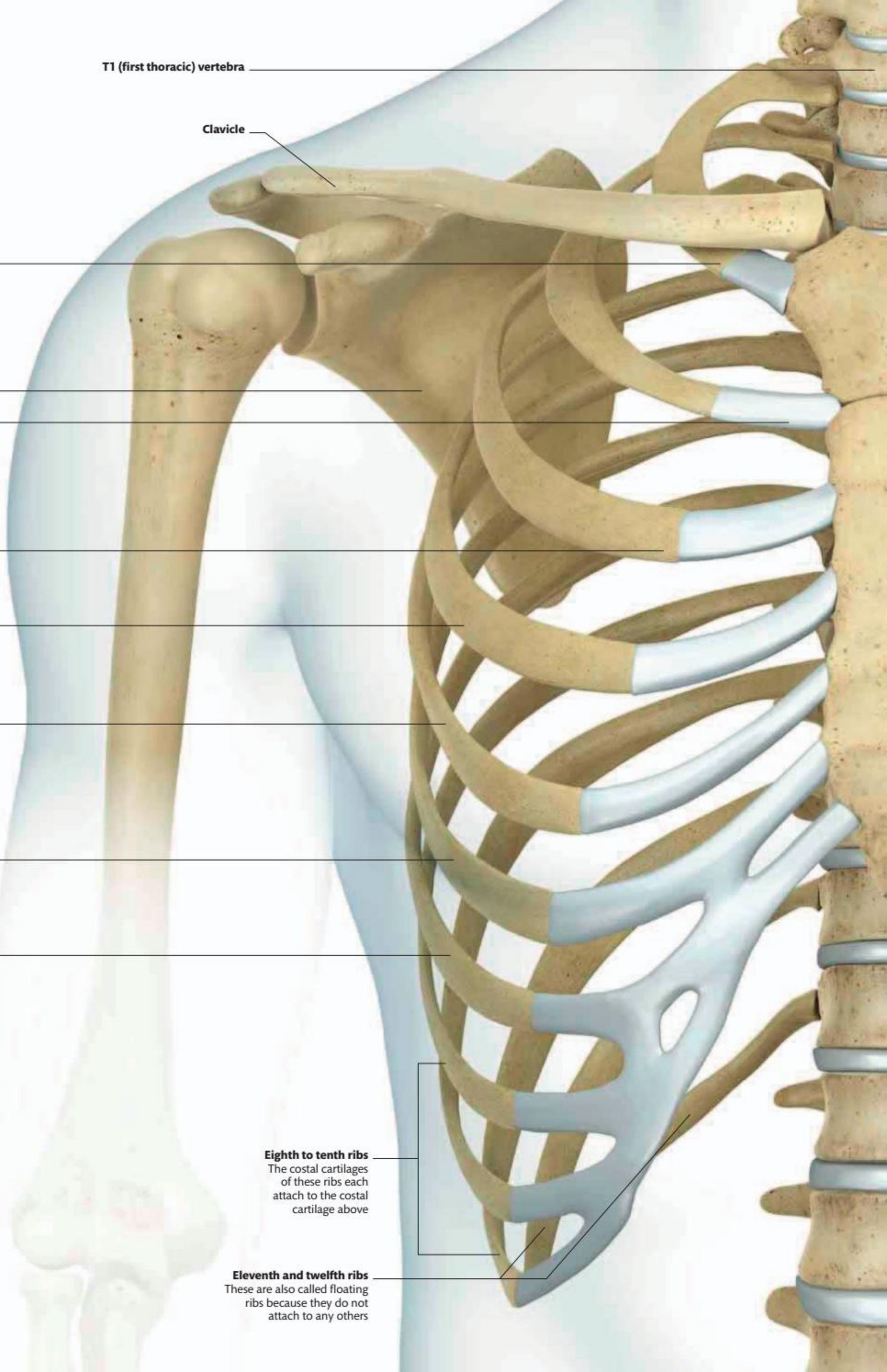
Zygomatic bone

ARTICULATED VIEW

DISARTICULATED VIEW

OSSICLES OF THE EAR

MALLEUS STAPES INCUS


T1 (first thoracic) vertebra
Clavicle
First rib
Smaller and more curved than all the other ribs; the thoracic inlet is formed by the first rib on each side, together with the manubrium sterni and the body of the T1 vertebra
Scapula
Second costal cartilage
The upper seven ribs are true ribs, and all attach directly to the sternum via costal cartilages
Third rib
Fourth rib
Fifth rib
Sixth rib
Seventh rib
Eighth to tenth ribs
The costal cartilages of these ribs each attach to the costal cartilage above
Eleventh and twelfth ribs
These are also called floating ribs because they do not attach to any others

Transverse process of T1
Each rib articulates with the transverse processes of the corresponding thoracic vertebra

Head of first rib
The heads of the ribs articulate with the bodies of vertebrae

Manubrium sterni
The sternum is shaped like a dagger or short sword; manubrium means handle or hilt in Latin

Manubriosternal joint

Body of sternum
Sternum comes from the Greek for breastbone

Xiphisternal joint

Xiphoid process
The tip of the sternum takes its name from the Greek word for sword

THORAX

The skeleton of the thorax plays several extremely important roles. It not only acts as an anchor for muscle attachment, but during breathing the ribs move up and out to increase the volume inside the thoracic cavity and draw air into the lungs. It also forms a protective cage around the precious organs inside: the heart and lungs. The bony thorax includes the 12 thoracic vertebrae, 12 pairs of ribs and costal cartilages, and the breastbone, or sternum. The upper seven ribs all articulate with the sternum via their costal cartilages. The eighth to the tenth costal cartilages each join to the cartilage above, creating the sweeping curve of the ribcage below the sternum on each side. The eleventh and twelfth ribs are short and do not join any other ribs—they are sometimes referred to as free or floating ribs.

ANTERIOR (FRONT)

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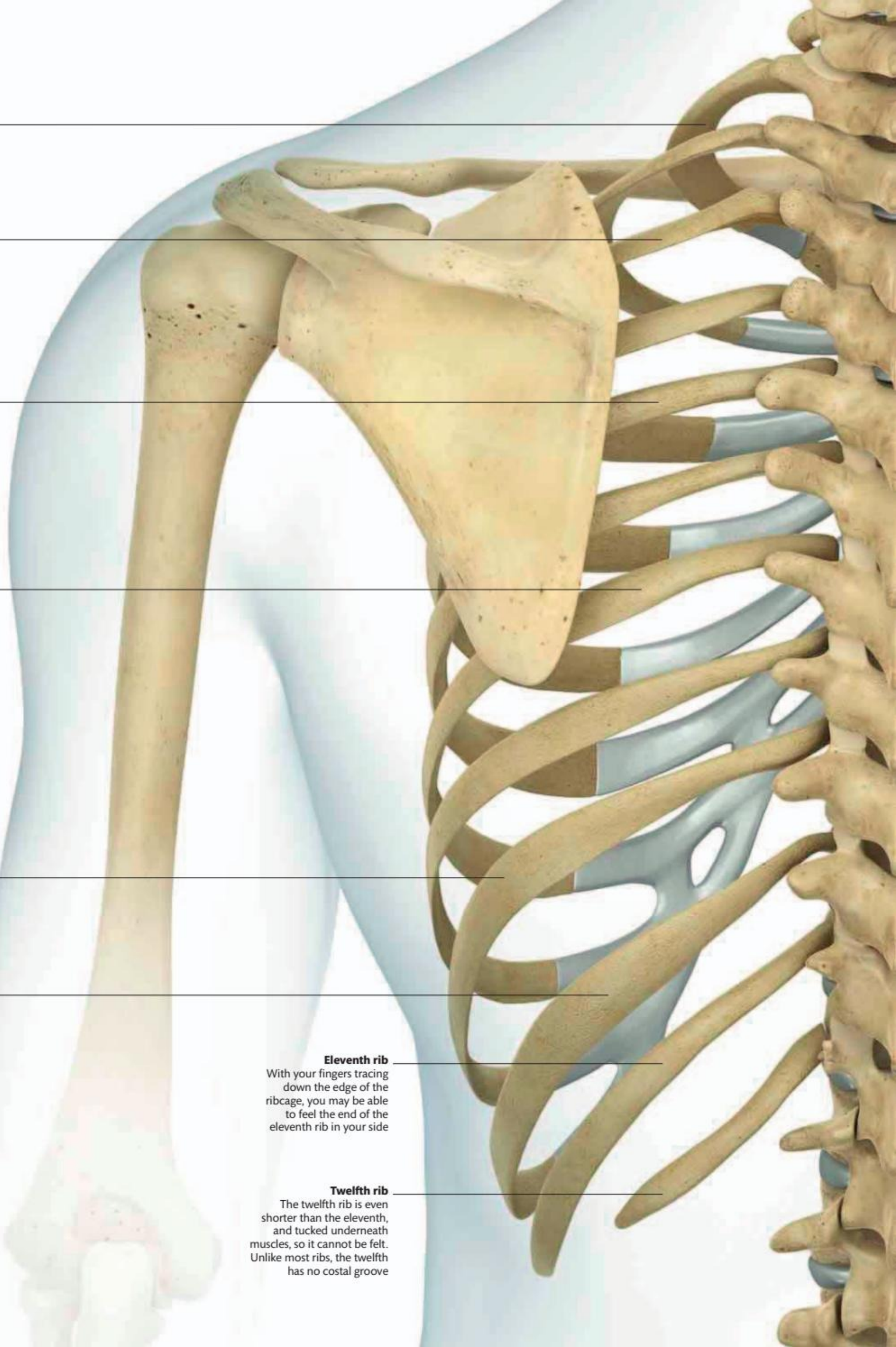
First rib
Third rib
Fifth rib
Seventh rib
Ninth rib
Tenth rib
Eleventh rib
With your fingers tracing down the edge of the ribcage, you may be able to feel the end of the eleventh rib in your side
Twelfth rib
The twelfth rib is even shorter than the eleventh, and tucked underneath muscles, so it cannot be felt. Unlike most ribs, the twelfth has no costal groove

C7 (seventh cervical vertebra)

Transverse process of T1

Costal groove

POSTERIOR (BACK)

THORAX

There are cartilaginous joints between the vertebrae at the back of the thorax, and between the parts of the sternum at the front. The joints between the ribs and the vertebrae at the back are synovial, allowing the ribs to move during breathing. When taking a breath, the anterior (front) ends of the upper ribs, along with the sternum, lift up and forward to increase the chest's front-to-back diameter, while the lower ribs move up and out, increasing the side-to-side diameter. Most ribs have a costal groove marking the lower border, on the inner surface, where nerves and vessels of the thoracic wall lie.

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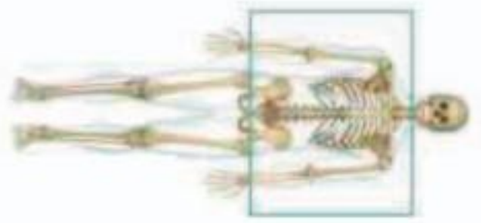
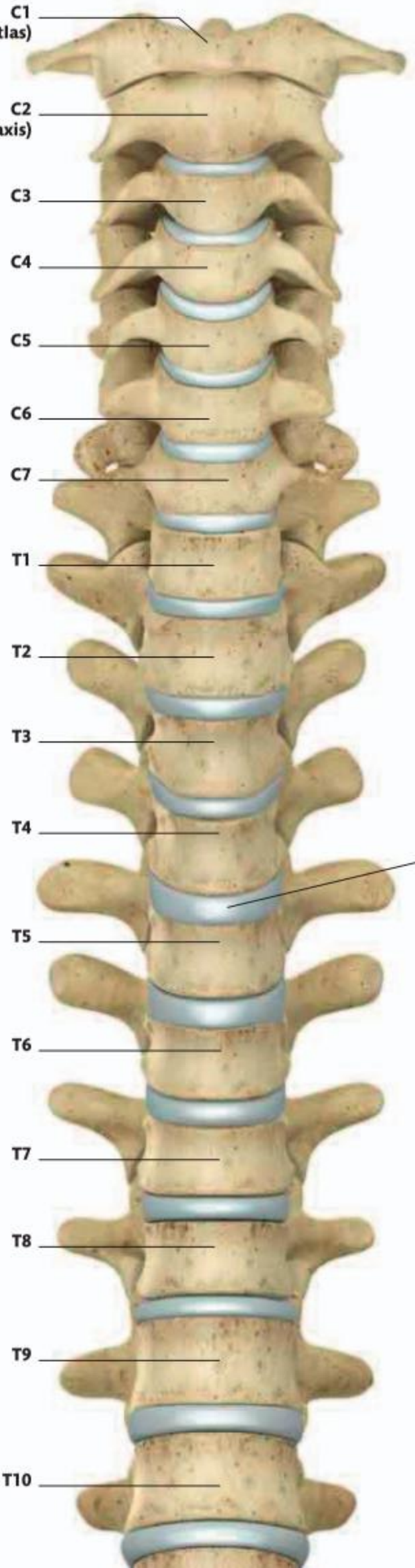
SPINE

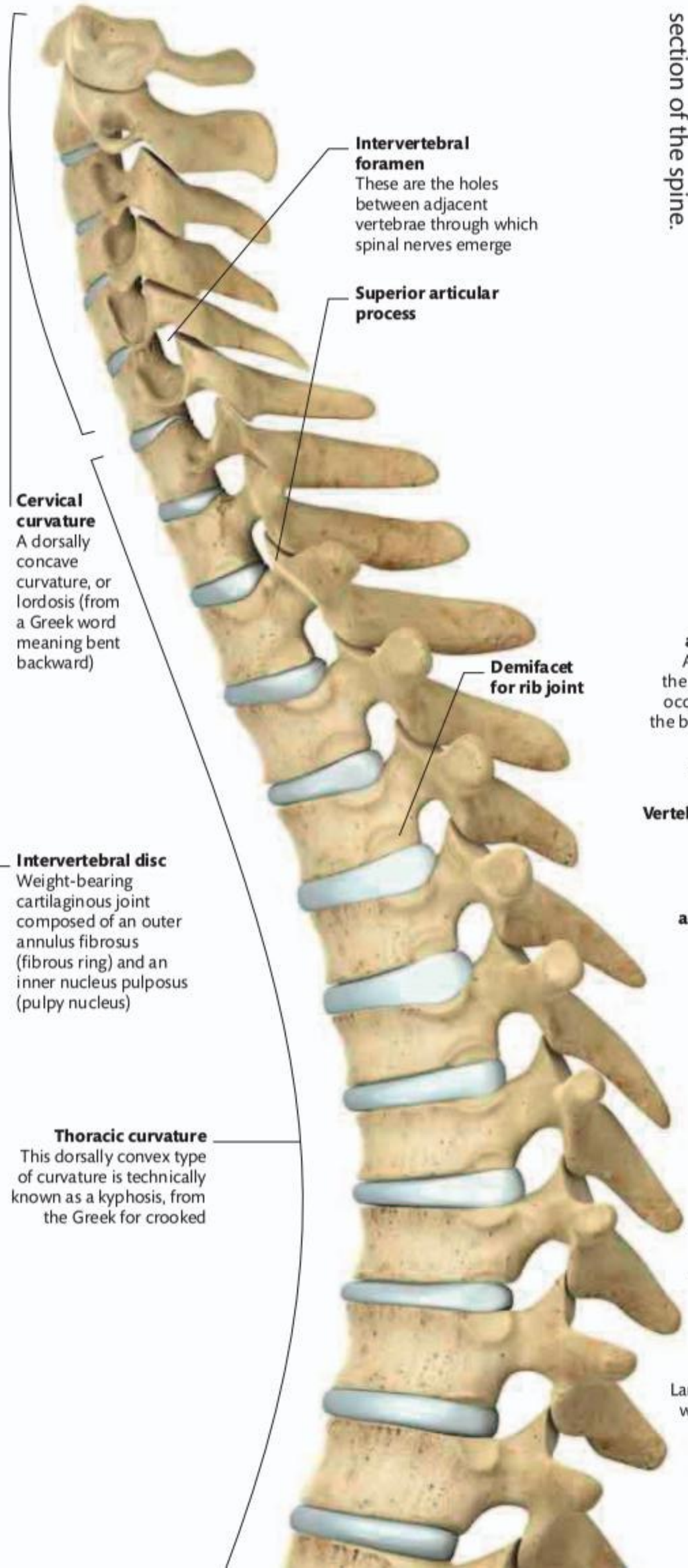


The spine, or vertebral column, occupies a central position in the skeleton, and plays several extremely important roles: it supports the trunk, encloses and protects the spinal cord, provides sites for muscle attachment, and contains blood-forming bone marrow. The entire vertebral column is about 28in (70cm) long in men, and 24in (60cm) long in women. About a quarter of this length is made up by the cartilaginous intervertebral discs between the vertebrae. The number of vertebrae varies from 32 to 35, mostly due to variation in the number of small vertebrae that make up the coccyx. Although there is a general pattern for a vertebra—most possess a body, a neural arch, and spinous and transverse processes—there are recognizable features that mark out the vertebrae of each section of the spine.



Cervical spine
(Seven vertebrae make up the spine in the neck)

Thoracic spine
(Twelve vertebrae, providing attachment for twelve pairs of ribs)



Intervertebral foramen
These are the holes between adjacent vertebrae through which spinal nerves emerge

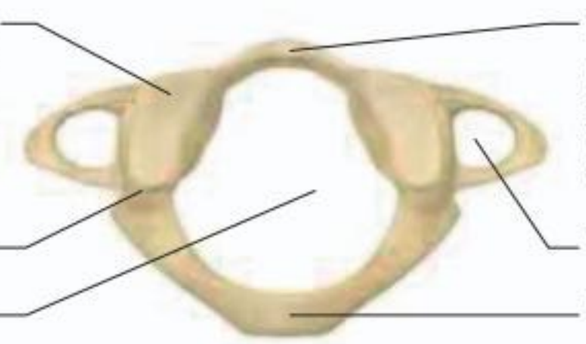
Superior articular process

Cervical curvature
A dorsally concave curvature, or lordosis (from a Greek word meaning bent backward)

Demifacet for rib joint

Intervertebral disc
Weight-bearing cartilaginous joint composed of an outer annulus fibrosus (fibrous ring) and an inner nucleus pulposus (pulpy nucleus)

Thoracic curvature
This dorsally convex type of curvature is technically known as a kyphosis, from the Greek for crooked



Superior articular facet
Articulates with the condyle of the occipital bone, on the base of the skull

Anterior arch
The atlas has no body, but it has an anterior arch that forms a joint with the dens of the axis

Lateral mass

Transverse foramen

Vertebral foramen

Posterior arch

ATLAS (C1)

Superior articular facet

Dens (odontoid peg)
This projection sticks up to articulate with the atlas

Transverse process

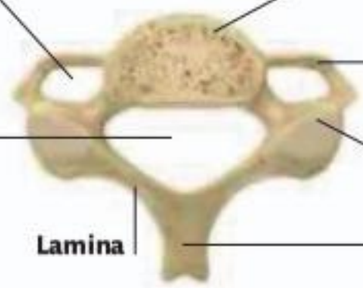
Body

Transverse foramen

Vertebral foramen

Spinous process

AXIS (C2)



Transverse foramen
The vertebral artery passes through here

Body
Made of cancellous bone containing blood-making bone marrow

Transverse process
For neck muscle attachment

Vertebral foramen
Large compared with the size of the body; contains the spinal cord

Superior articular facet

Lamina

Spinous process
Tends to be small and forked; for the attachment of back muscles

CERVICAL

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T11
T12
L1
L2
L3
L4
L5
Lumbar spine (Five vertebrae)
S1
S2
S3
S4
S5
co1
co2
co3
Sacrum (Five fused vertebrae)
Coccyx (Three to five vertebrae)

ANTERIOR (FRONT)

Lumbar curvature
Appears about a year after birth, when an infant starts to walk

Zygapophyseal (facet) joint
Synovial joints between the adjacent articular processes allow variable degrees of movement in different sections of the spine; in disk degeneration, these joints end up bearing more weight and may be a source of back pain

Inferior articular process

Sacral curvature

SIDE

Transverse process
Forms a joint with the ribs on each side

Body
Thoracic vertebrae have heart-shaped bodies

Vertebral foramen

Superior articular facet

Lamina

Spinous process
Long and sloping in the thoracic spine

THORACIC

Vertebral foramen

Pedicle

Superior articular facet

Transverse process
Long and thin

Lamina

Body
Vertebral bodies are larger at lower spinal levels—they have progressively more weight to bear; bodies of lumbar vertebrae are kidney-shaped, and large compared with the size of the vertebral foramen

Spinous process
Large and square in the lumbar spine

LUMBAR

Lateral part
Formed from fused lateral parts of the sacral segments; articulates with the pelvis at the sacroiliac joint

Body
Five vertebrae fuse during development to form the sacrum

Anterior sacral foramen
Anterior branches of sacral spinal nerves pass through these holes; posterior branches emerge through the posterior foramina

Facet for coccyx

SACRUM

Coccygeal cornu
Articulates with sacral cornu

Facet for apex of sacrum

COCCYX

ABDOMEN AND PELVIS

The bony boundaries of the abdomen include the five lumbar vertebrae at the back, the lower margin of the ribs above, and the pubic bones and iliac crest of the pelvic bones below. The abdominal cavity itself extends up under the ribcage, as high as the gap between the fifth and sixth ribs, due to the domed shape of the diaphragm. This means that some abdominal organs, such as the liver, stomach, and spleen are, in fact, largely tucked up under the ribs. The pelvis is a basin shape, and is enclosed by the two pelvic (or innominate) bones, at the front and sides, and by the sacrum at the back. Each pelvic bone is made of three fused bones: the ilium at the rear, the ischium at the lower front, and the pubis above it.

Twelfth rib

Lumbar vertebrae
The lumbar section of the spine forms part of the posterior abdominal wall

Iliac crest
Upper edge of the ilium—one of the three bones that make up the bony pelvis; it can be felt easily through the skin

Sacroiliac joint
A synovial joint between the sacrum and ilium

Iliac fossa
The concavity (concave surface) of the ilium gives attachment to the iliacus muscle and supports the intestines

Sacrum

Pelvic bone
Each of the two large pelvic bones is made up of ilium, pubis, and ischium

Coccyx

Superior pubic ramus
The upper branch of the pubic bone

Body of ischium

Ischiopubic ramus

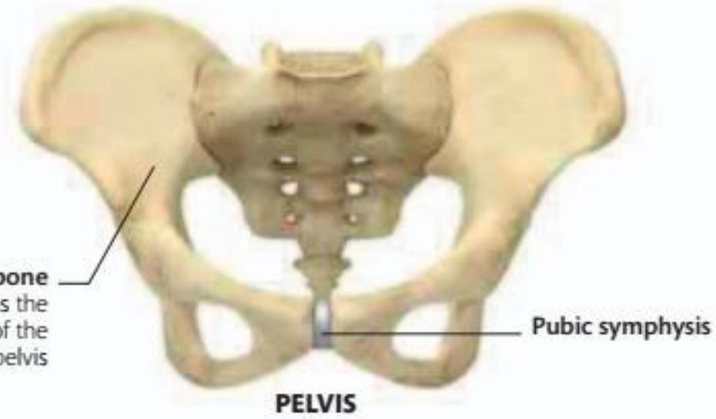
Ischial tuberosity

Femur

ANTERIOR (FRONT)

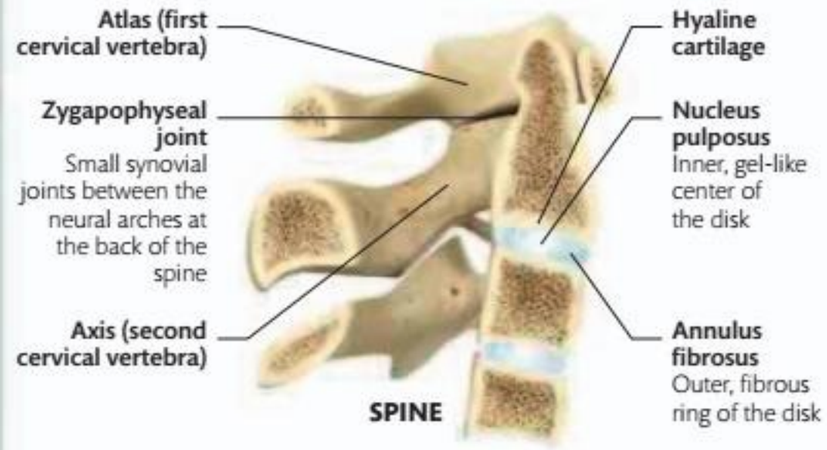
CARTILAGINOUS JOINTS

Semi-movable cartilaginous joints are formed by bones separated by a disc of resilient and compressible fibrocartilage, which allows limited movement. Cartilaginous joints include the junctions between ribs and costal cartilages, joints between the components of the sternum, and the pubic symphysis. The intervertebral discs are also specialized cartilaginous joints.



PELVIS

Pubic symphysis
At the front of the bony pelvis, the two pubic bones meet each other. The articular surface of each is covered with hyaline cartilage, with a pad of fibrocartilage joining them in the middle.



SPINE

Intervertebral disc
Each fibrocartilage pad or disk between vertebrae is organized into an outer annulus fibrosus and an inner nucleus pulposus.

Anterior superior iliac spine
This is the anterior (front) end of the iliac crest

Ala of sacrum
The bony masses to the sides of the sacrum are called the alae, which means wings in Latin

Anterior sacral foramina
Anterior (frontal) branches of the sacral spinal nerves pass out through these holes

Pubic symphysis
A cartilaginous joint between the two pubic bones

Pubic tubercle
This small bony projection provides an attachment point for the inguinal ligament

Obturator foramen
This hole is largely closed over by a membrane, with muscles attaching on either side; its name comes from the Latin for stopped up

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ABDOMEN AND PELVIS

The orientation of the facet joints (the joints between the vertebrae) of the lumbar spine means that rotation of the vertebrae is limited, but flexion and extension can occur freely. There is, however, rotation at the lumbosacral joint, which allows the pelvis to swing during walking. The sacroiliac joints are unusual in that they are synovial joints (which are usually very movable), yet they are particularly limited in their movement. This is because strong sacroiliac ligaments around the joints bind the ilium (part of the pelvic bone) tightly to the sacrum on each side. Lower down, the sacrospinous and sacrotuberous ligaments, stretching from the sacrum and coccyx to the ilium, provide additional support and stability.

Iliac crest

Gluteal surface of ilium
The gluteal muscles attach to the pelvis here

Posterior superior iliac spine
This is the back end of the iliac crest

Sacroiliac joint

Sacrum

Body of pubis
The wide, flat portion of the pubic bone

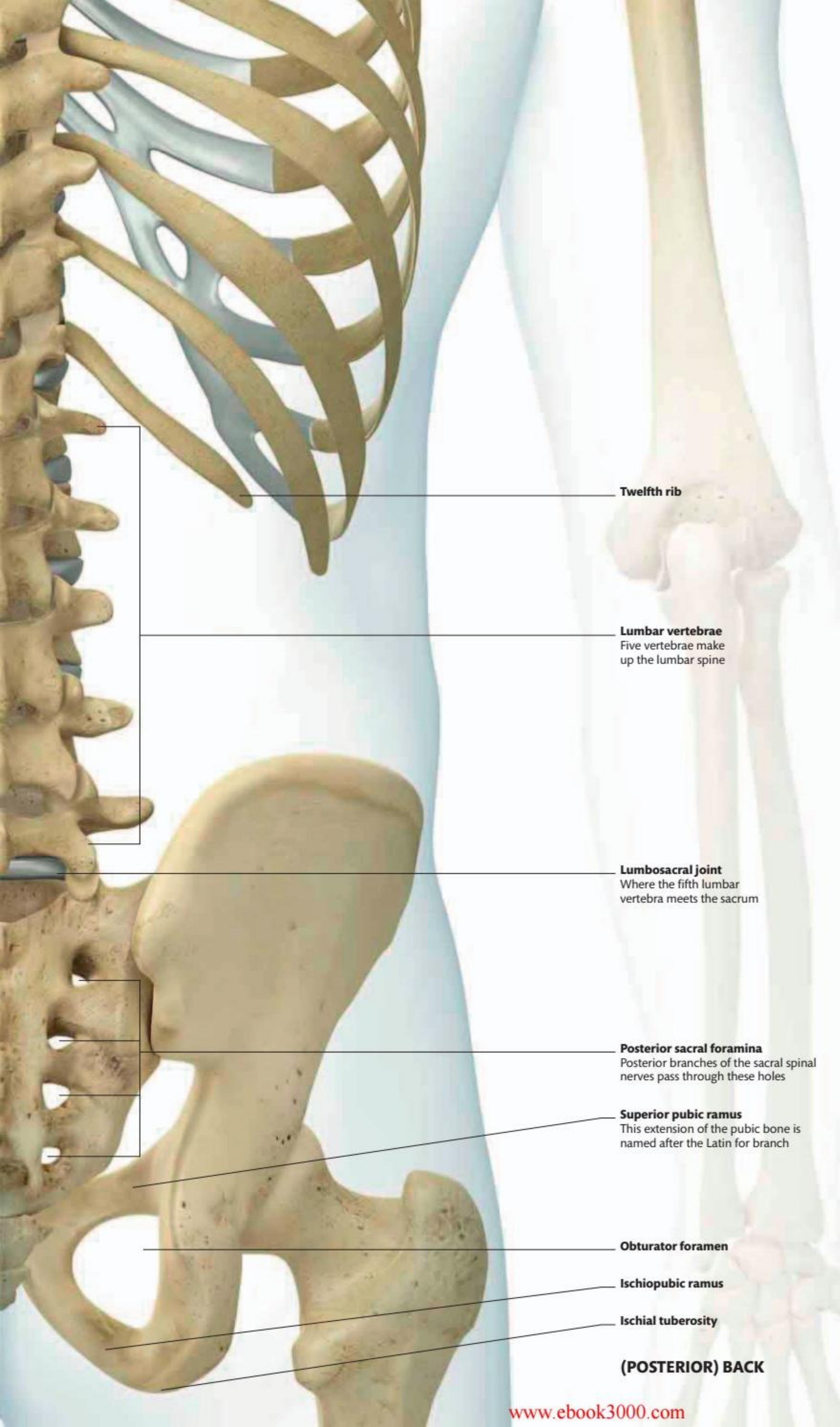
Ischial spine
This projection from the ischium forms the attachment point for the sacrospinous ligament of the pelvis

Greater trochanter
Gluteal muscles attach here

Coccyx

Lesser trochanter
Attachment point for the psoas muscle

Femur



Twelfth rib

Lumbar vertebrae
Five vertebrae make up the lumbar spine

Lumbosacral joint
Where the fifth lumbar vertebra meets the sacrum

Posterior sacral foramina
Posterior branches of the sacral spinal nerves pass through these holes

Superior pubic ramus
This extension of the pubic bone is named after the Latin for branch

Obturator foramen

Ischiopubic ramus

Ischial tuberosity

(POSTERIOR) BACK

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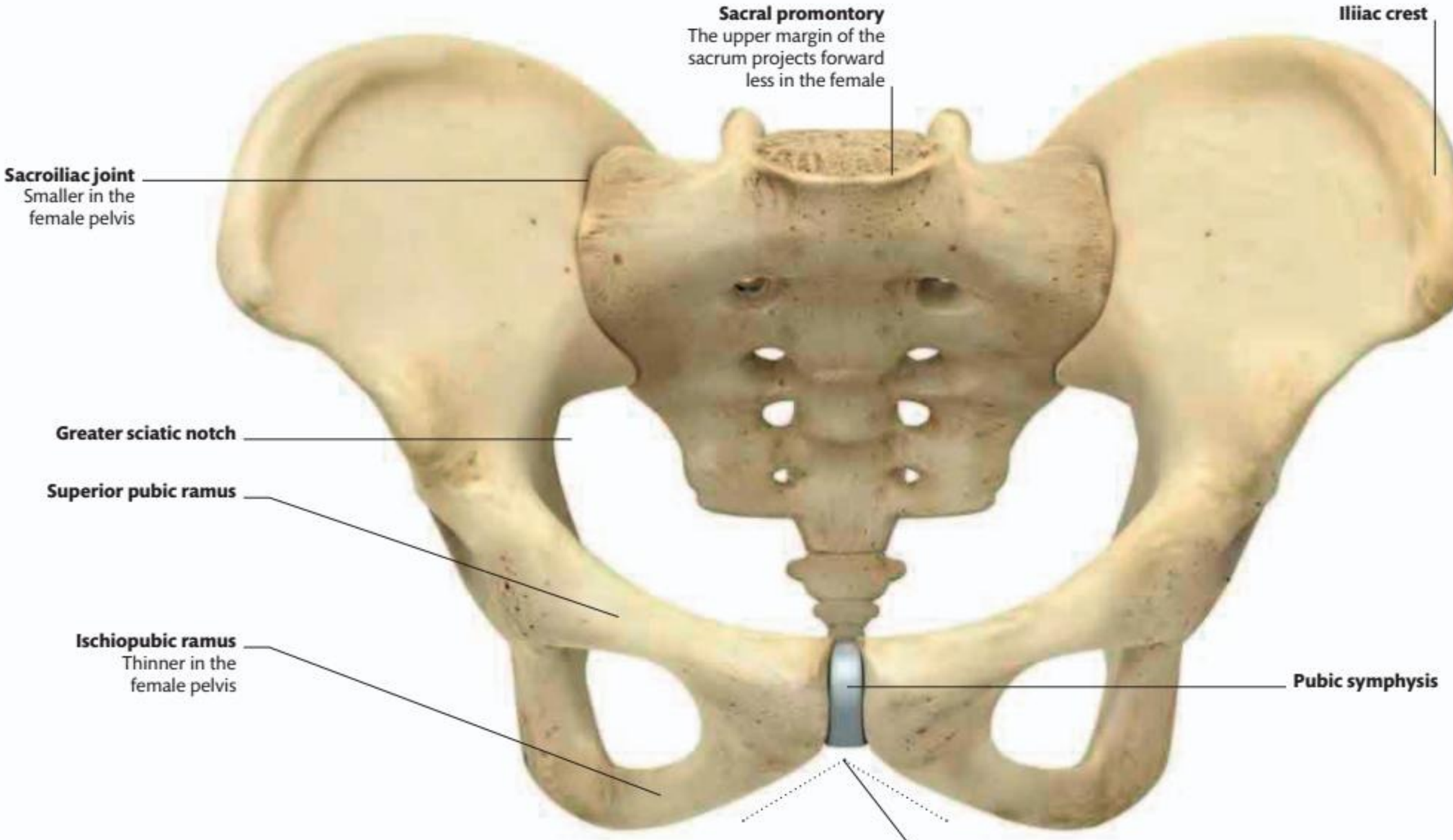
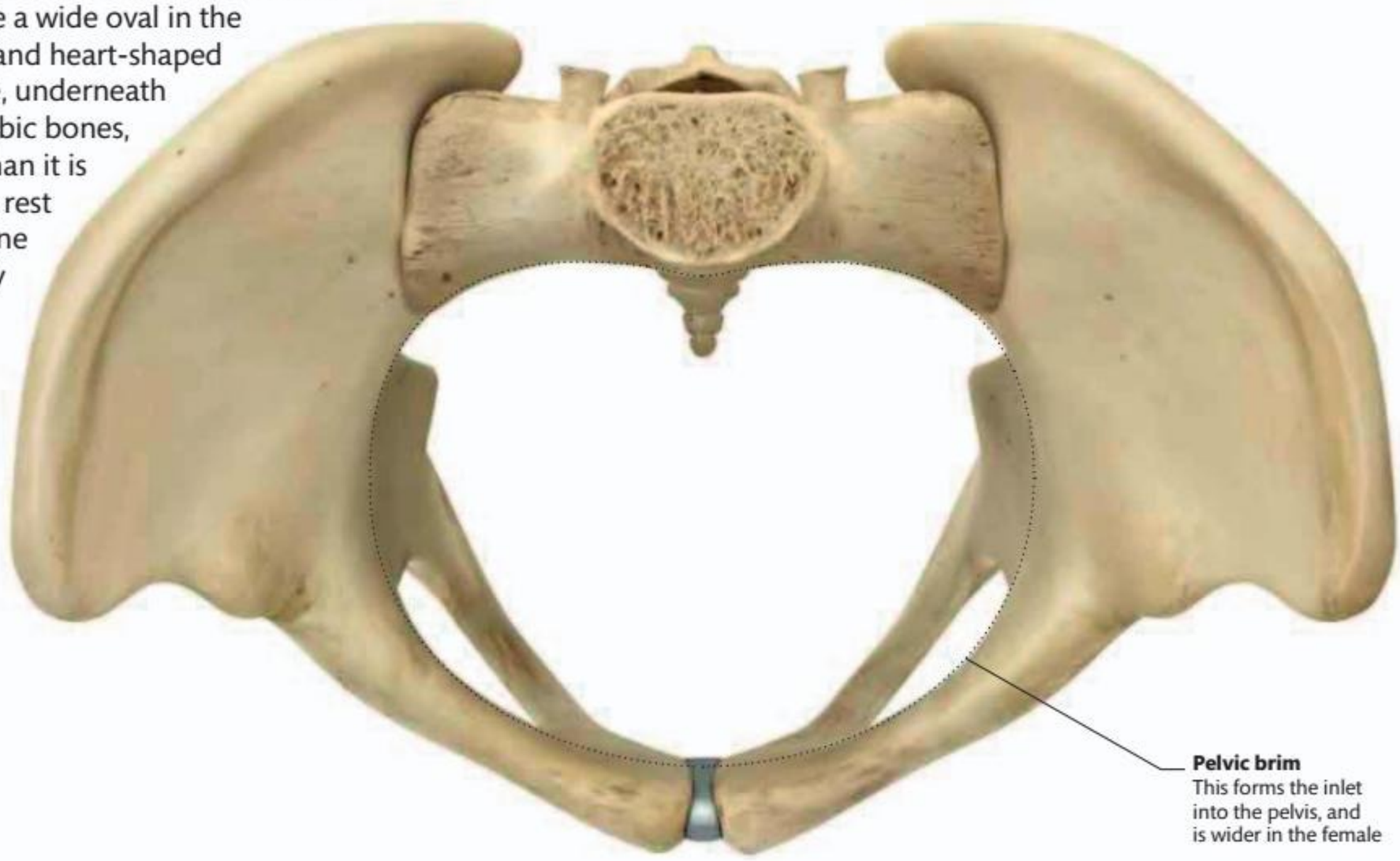


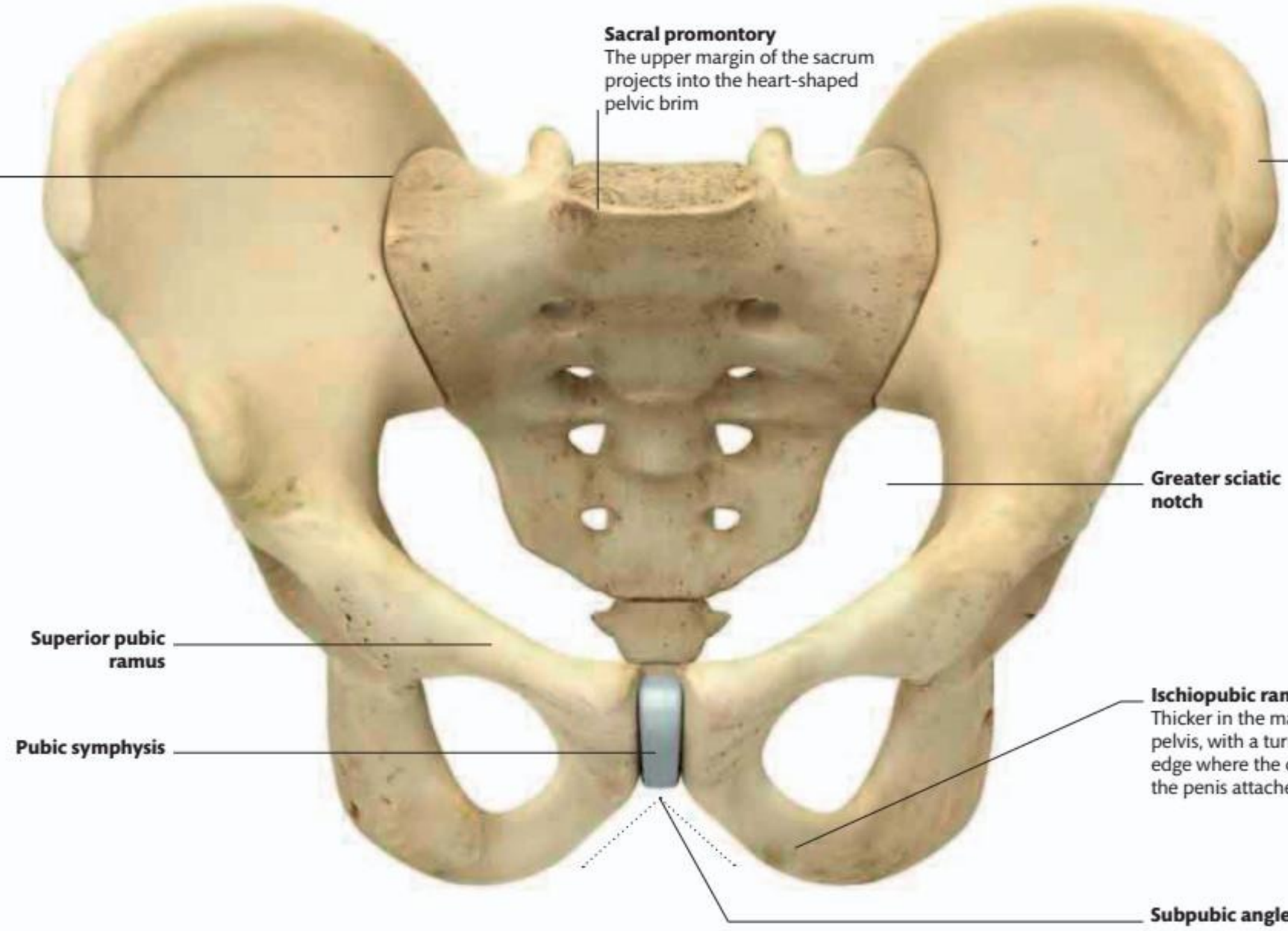
FEMALE PELVIS ANTERIOR (FRONT)

PELVIS

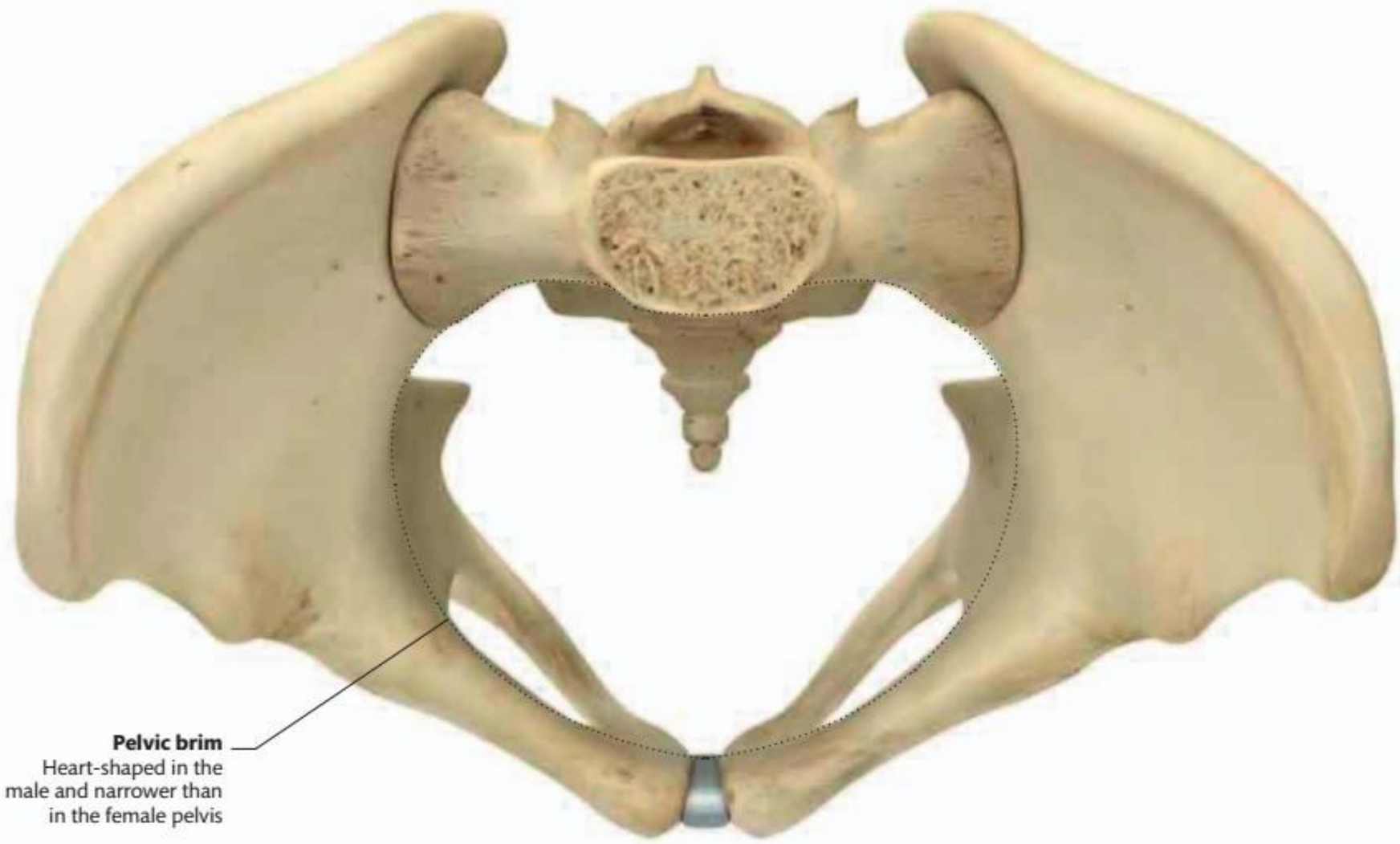
The bony pelvis is the part of the skeleton that is most different between the sexes, because the pelvis in the female has to accommodate the birth canal, unlike the male pelvis. Comparing the pelvic bones of a man and a woman, there are obvious differences between the two. The shape of the ring formed by the sacrum and the two pelvic bones –the pelvic brim–tends to be a wide oval in the woman and much narrower and heart-shaped in a man. The subpubic angle, underneath the joint between the two pubic bones, is much narrower in a man than it is in with a woman. As with the rest of the skeleton, the pelvic bone also tends to be more chunky or robust in a man, with more obvious ridges where muscles attach.



FEMALE PELVIS VIEWED FROM ABOVE



MALE PELVIS ANTERIOR (FRONT)



MALE PELVIS VIEWED FROM ABOVE

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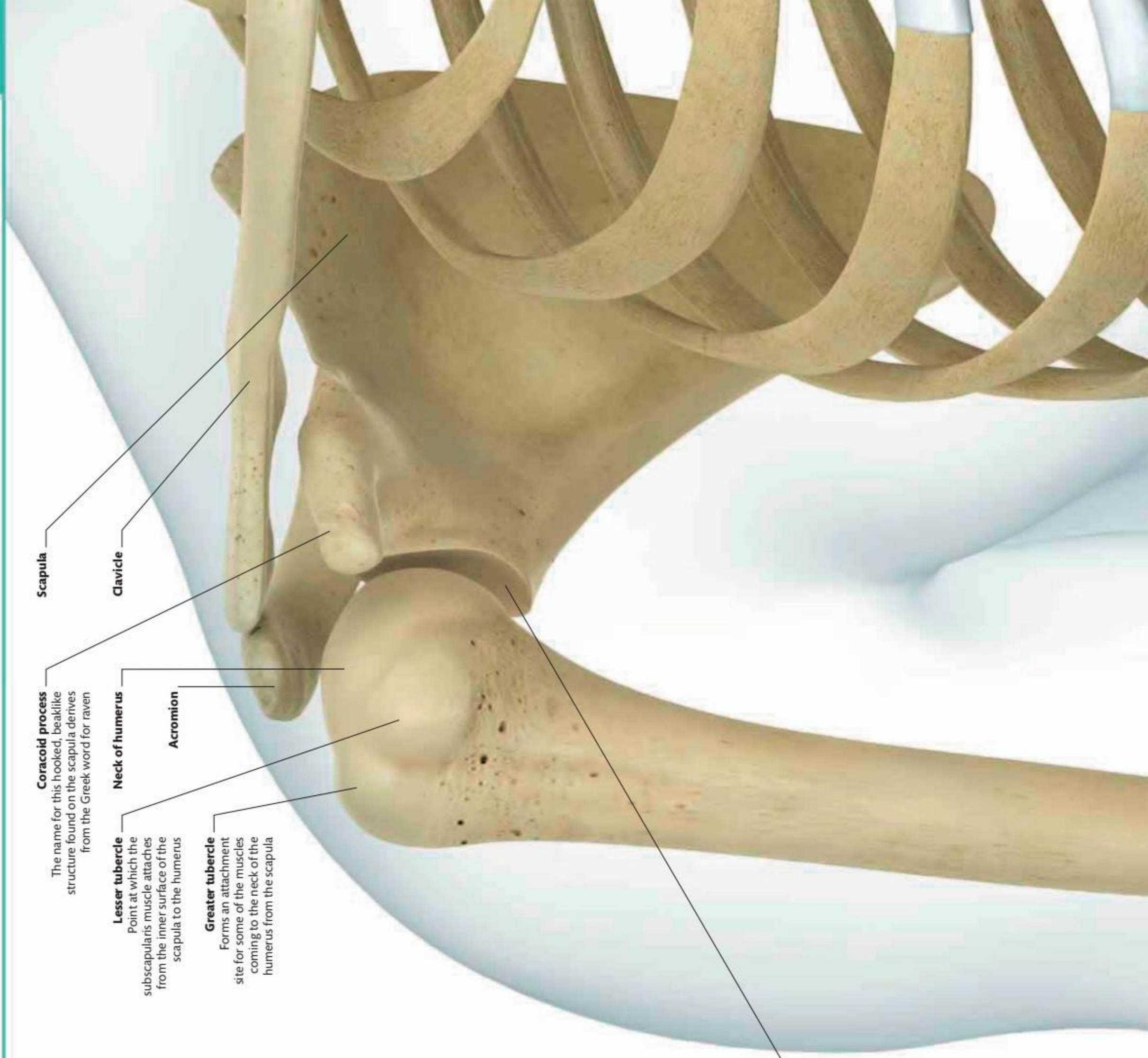
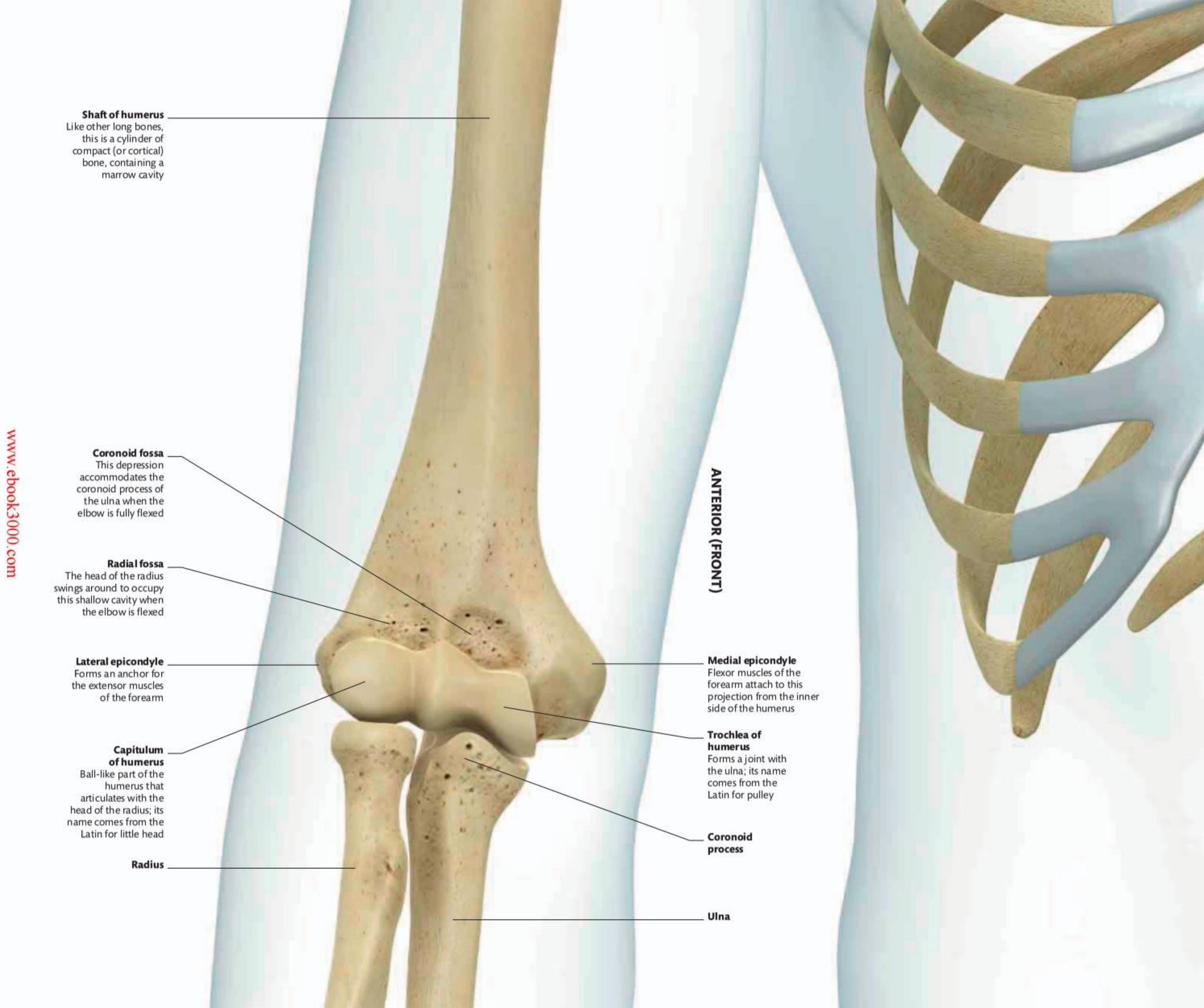


SHOULDER AND UPPER ARM

The scapula and clavicle make up the shoulder girdle, which anchors the arm to the thorax. This is a very mobile attachment—the scapula "floats" on the ribcage, attached to it by muscles only (rather than by a true joint) that pull the scapula around on the underlying ribs, altering the position of the shoulder joint. The clavicle has joints—it articulates with the acromion of the scapula laterally (at the side) and the sternum at the other end—and helps hold the shoulder out to the side while allowing the scapula to move around. The shoulder joint, the most mobile joint in the body, is a ball-and-socket joint, but the socket is small and shallow, allowing the ball-shaped head of the humerus to move freely.



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SHOULDER AND UPPER ARM

The back of the scapula is divided into two sections by its spine. The muscles that attach above this spine are called supraspinatus; those that attach below are called infraspinatus. They are part of the rotator cuff muscle group, which enables shoulder movements and stabilizes the shoulder joint. The spine of the scapula runs to the side and projects out above the shoulder joint to form the acromion, which can be easily felt on the top of the shoulder. The scapula rests in the position shown here when the arm is hanging at the side of the body. If the arm is abducted (raised to the side), the entire scapula rotates so that the glenoid cavity points upward and the inferior angle moves outward.

Supraspinous fossa
This is the depression above the spine of the scapula, where the supraspinatus muscle is attached

Spine of scapula

Clavicle

Glenoid cavity

Acromion

Infraspinous fossa
The infraspinatus muscle attaches to this part of the scapula—below its spine

Inferior angle

Spiral groove
This faint line marks where the radial nerve spirals around the posterior aspect of the humerus

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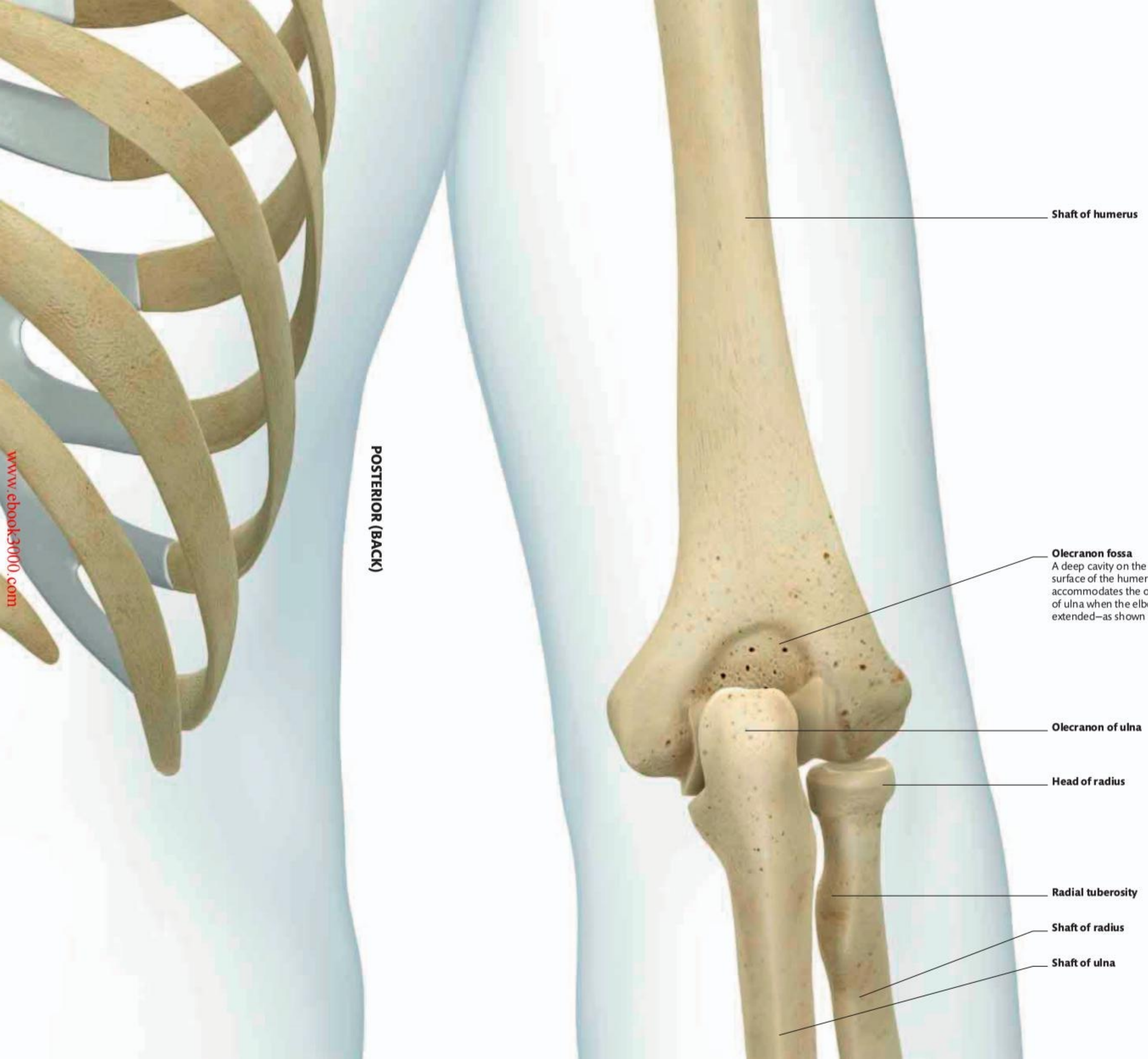
POSTERIOR (BACK)



Shaft of humerus

Olecranon fossa
A deep cavity on the posterior surface of the humerus; it accommodates the olecranon of ulna when the elbow is fully extended—as shown here

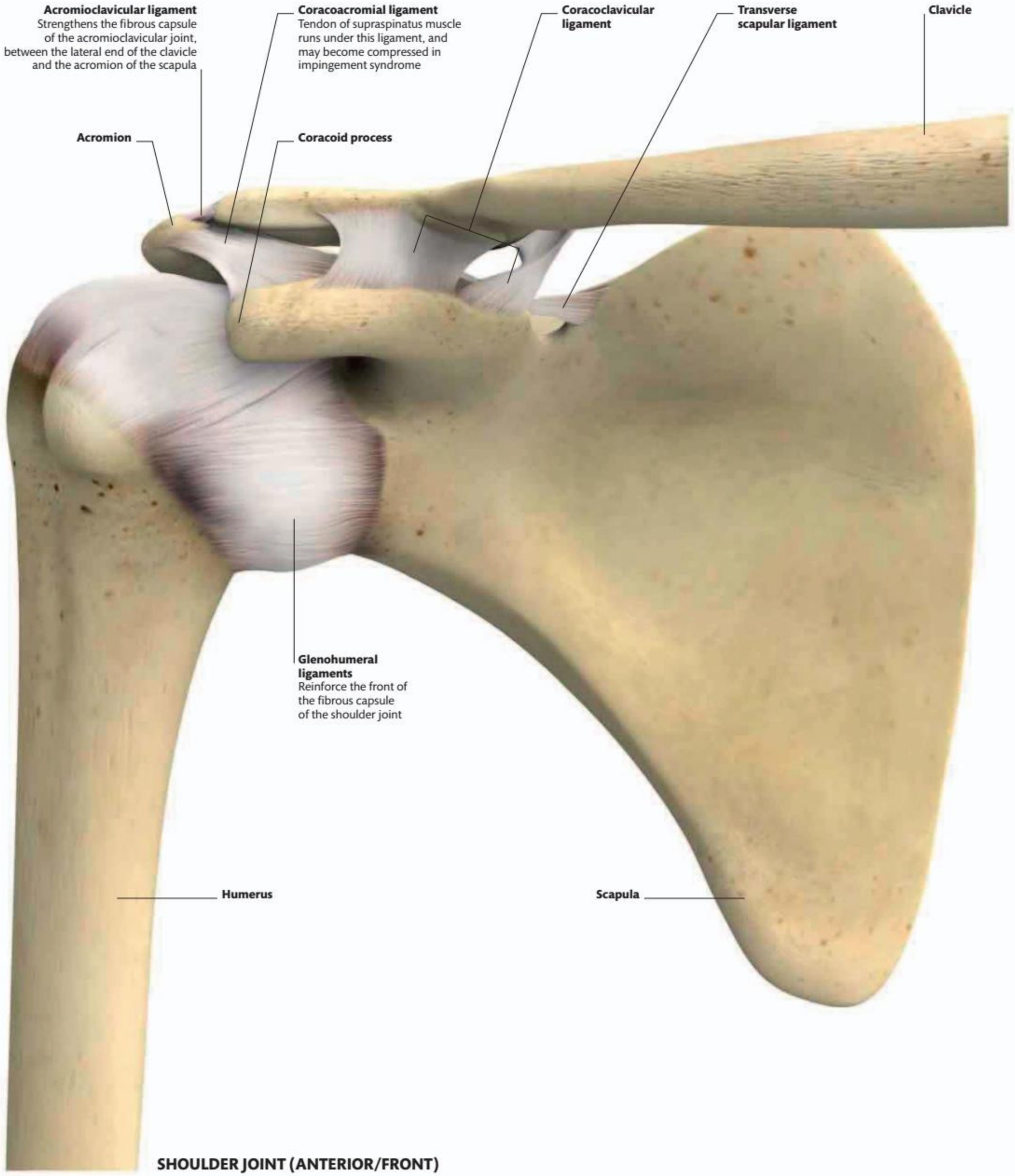
Olecranon of ulna

Head of radius

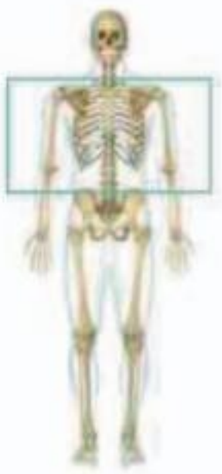
Radial tuberosity

Shaft of radius

Shaft of ulna

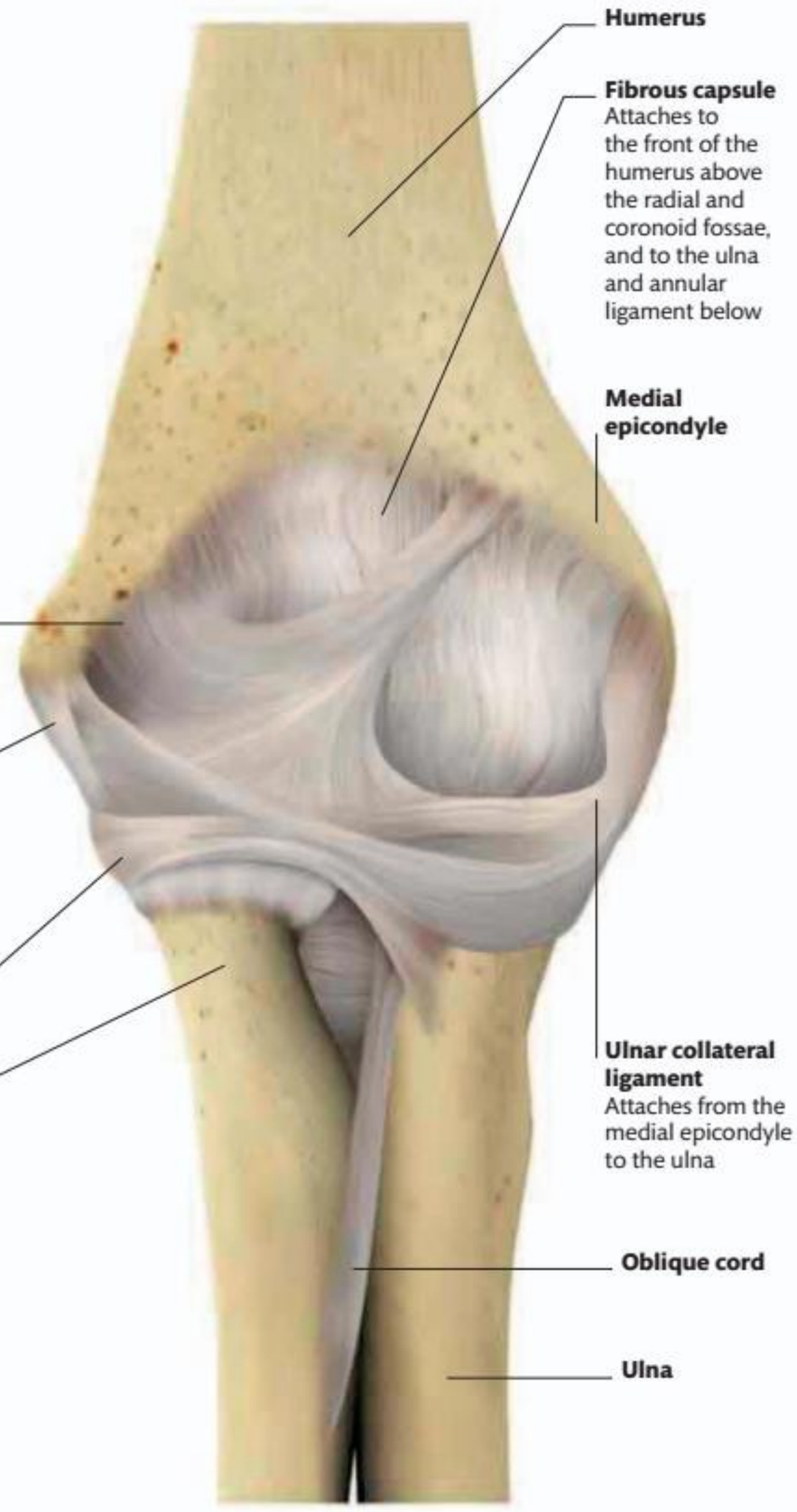


SHOULDER JOINT (ANTERIOR/FRONT)

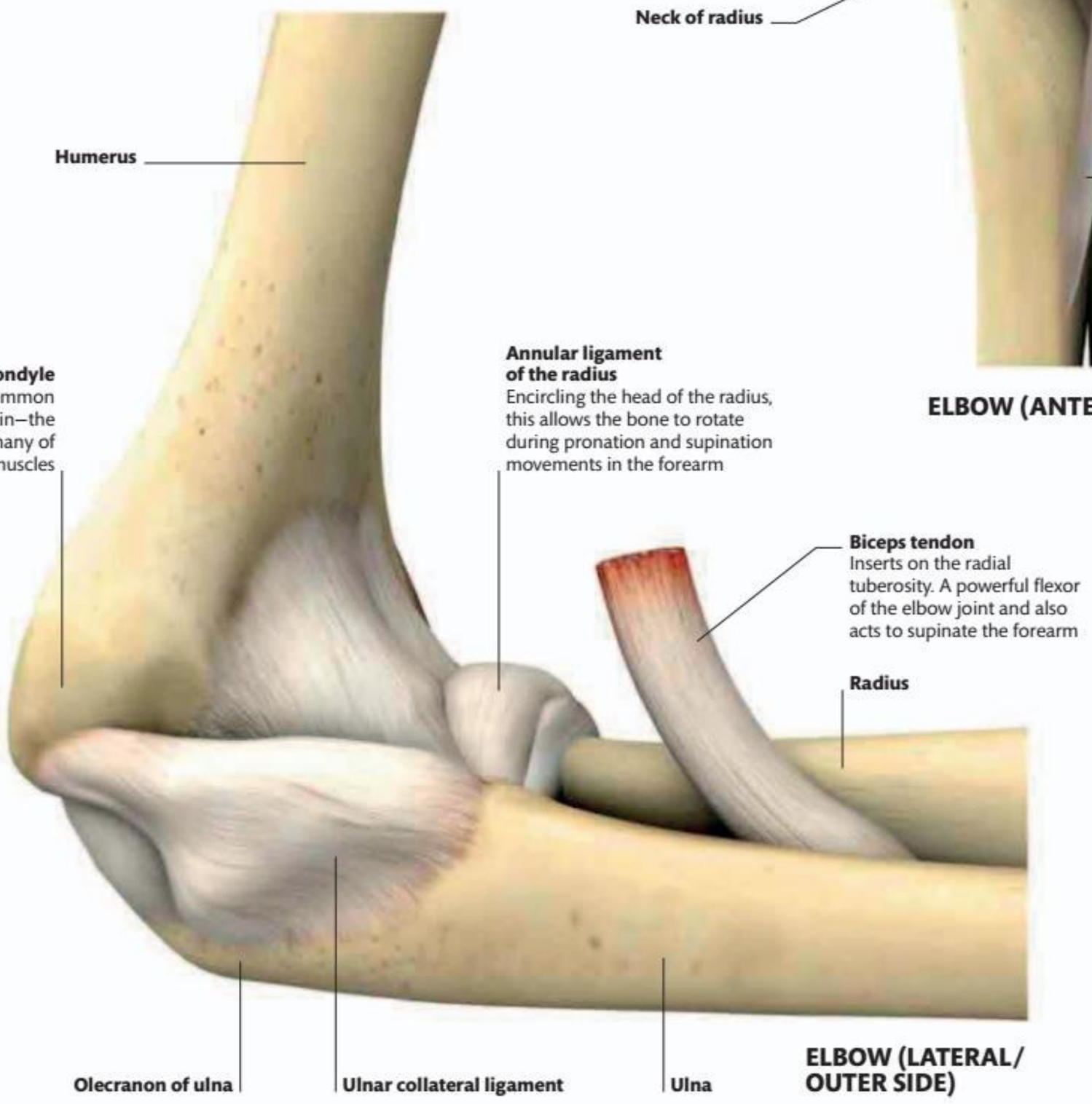


SHOULDER AND UPPER ARM

In any joint, there is always a play off between mobility and stability. The extremely mobile shoulder joint is therefore naturally unstable, and so it is not surprising that this is the most commonly dislocated joint in the body. The coracoacromial arch, formed by the acromion and coracoid process of the scapula with the strong coracoacromial ligament stretching between them, prevents upward dislocation; when the head of the humerus dislocates, it usually does so in a downward direction. The elbow joint is formed by the articulation of the humerus with the forearm bones: the trochlea articulates with the ulna, and the capitulum with the head of the radius. The elbow is a hinge joint, stabilized by collateral ligaments on each side.



ELBOW (ANTERIOR/FRONT)



ELBOW (LATERAL/ OUTER SIDE)

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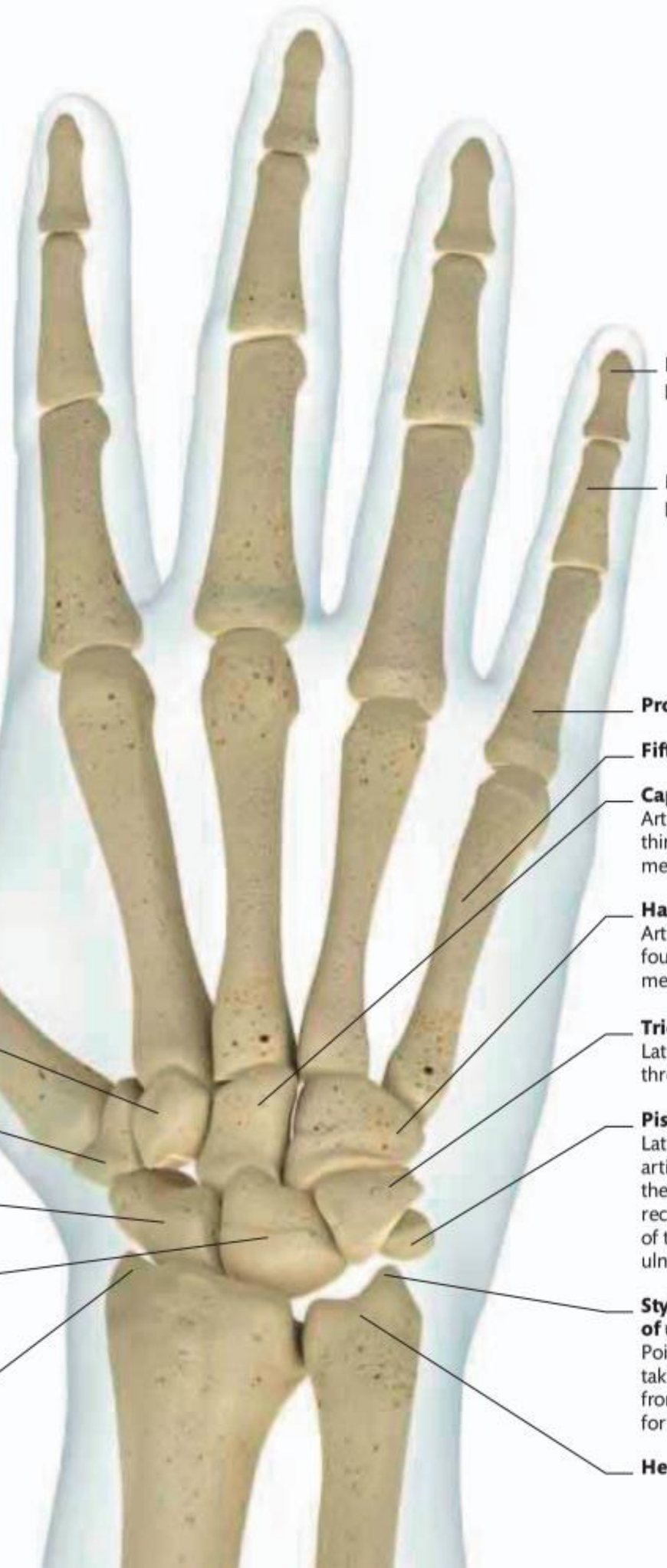
POSTERIOR (BACK)



Distal phalanx

Middle phalanx

Distal phalanx

Proximal phalanx

Proximal phalanx

Fifth metacarpal

First metacarpal

Capitate
Articulates with third and fourth metacarpals

Trapezoid
Articulates with second metacarpal of index finger

Hamate
Articulates with fourth and fifth metacarpals

Trapezium
Articulates with first metacarpal of thumb

Triquetral
Latin for three-cornered

Scaphoid
The most commonly fractured wrist bone

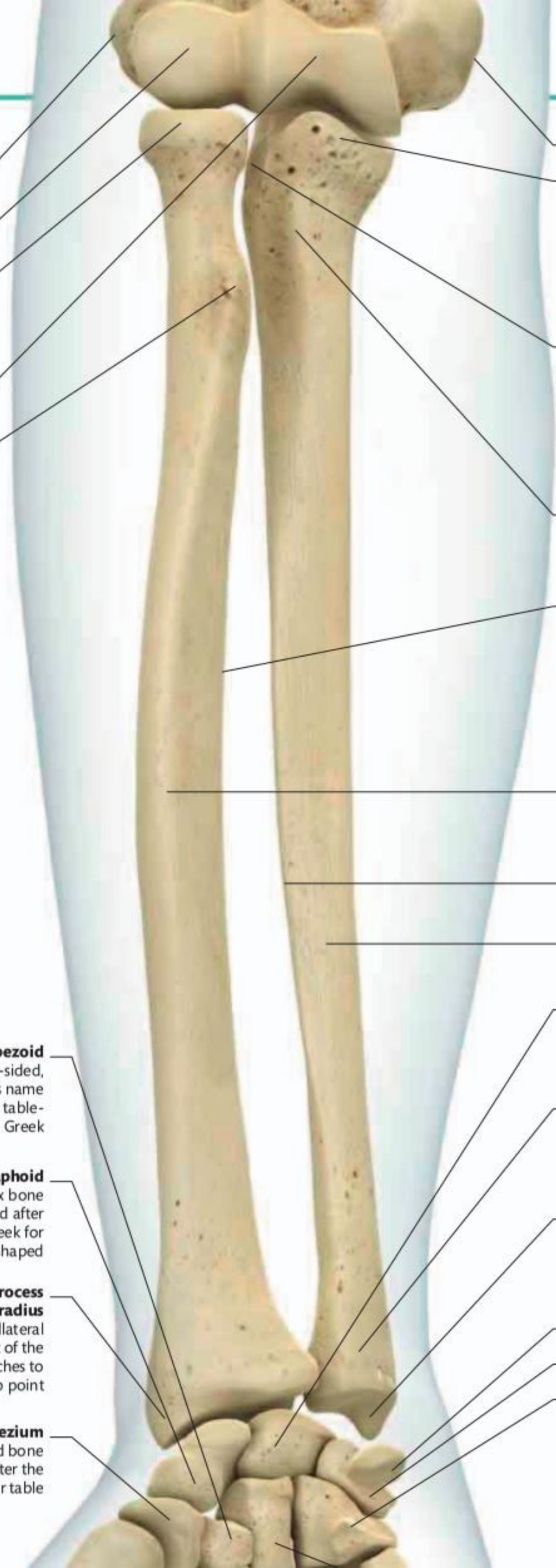
Pisiform
Latin for pea-shaped; articulates with the triquetral, and receives the tendon of the flexor carpi ulnaris muscle

Lunate
Articulates with scaphoid and radius to form wrist joint; this is the most commonly dislocated carpal (wrist) bone

Styloid process of ulna
Pointed projection taking its name from the Greek for pillar-shaped

Styloid process of radius

Head of ulna



Lateral epicondyle

Capitulum of humerus

Head of radius
Bowl-shaped surface articulates with the capitulum of humerus

Trochlea of humerus

Radial tuberosity
Biceps tendon attaches here

Medial epicondyle

Coronoid process
Forms anterior margin of the trochlear notch of the ulna, which accommodates the trochlea of the humerus

Radial notch of ulna
This concave surface articulates with the head of the radius, forming the proximal radioulnar joint

Tuberosity of ulna
Brachialis muscle attaches here

Interosseous border of radius
Sharp ridges on facing edges of the radius and ulna provide attachment for the forearm's interosseous membrane

Shaft of radius
Like the ulna, this is triangular in cross section

Interosseous border of ulna

Shaft of ulna

Lunate
Crescent-shaped bone named after the Latin for moon

Trapezoid
Also four-sided, this bone's name means table-shaped in Greek

Head of ulna
Articulates with lower end of the radius, at the distal radioulnar joint

Scaphoid
Convex bone named after the Greek for boat-shaped

Styloid process of ulna
Where the ulnar collateral ligament attaches

Styloid process of radius
The radial collateral ligament of the wrist attaches to this sharp point

Pisiform

Triquetral

Trapezium
Four-sided bone named after the Greek for table

Hamate
One of the carpal bones, along with the other bones between the radius and ulna

LOWER ARM AND HAND

The two forearm bones, the radius and ulna, are bound together by a flat sheet of ligament called the interosseous membrane, and by synovial joints between the ends of the two bones. Known as radioulnar joints, these joints allow the radius to move around the ulna. Hold your hand out in front of you, palm upward. Now turn your hand so that the palm faces the ground. This movement is called pronation, and is achieved by bringing the radius to cross over the ulna. The movement that returns the palm to an upward-facing position is called supination. Since the forearm bones are bound together by ligaments, joints, and muscles, it is common for both bones to be involved in a serious forearm injury. Often, one bone is fractured and the other dislocated. The skeleton of the hand comprises the eight carpal bones (bones between the radius and ulna), five metacarpals, and fourteen phalanges.

Capitate
Meaning headed in Latin, this bone looks like a tiny head on a neck

Fifth metacarpal
Metacarpals in the palm link carpals to phalanges

Proximal phalanx
Each finger has three phalanges: proximal, middle, and distal

Middle phalanx

Distal phalanx

ANTERIOR (FRONT)

First metacarpal

Proximal phalanx

Distal phalanx of thumb
The thumb has just two phalanges: proximal and distal

Medial epicondyle of humerus

Shaft of radius
The shafts of the radius and ulna contain marrow cavities

Shaft of ulna

Interosseous border of radius

Interosseous border of ulna

Radial tuberosity

Supinator crest

Head of radius

Lateral epicondyle of humerus

Olecranon of ulna

Olecranon fossa of humerus

Humerus

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HAND AND WRIST JOINTS

The radius widens out at its distal (lower) end to form the wrist joint with the closest two carpal bones, the lunate and scaphoid. This joint allows flexion, extension, adduction, and abduction (see pp.16–17). There are also synovial joints (see p.60) between the carpal bones in the wrist, which increase the range of motion during wrist flexion and extension. Synovial joints between metacarpals and phalanges allow us to spread or close our fingers, as well as flexing or extending the whole finger. Joints between the individual finger bones, or phalanges, enable fingers to bend and straighten. In common with many other primates, humans have opposable thumbs. The joints at the base of the thumb are shaped differently from those of the fingers. The joint between the metacarpal of the thumb and the wrist bones is especially mobile and allows the thumb to be brought across the palm of the hand so that the tip of the thumb can touch the other fingertips.

Distal phalanx

Middle phalanx

Distal interphalangeal joint

Proximal interphalangeal joint
The interphalangeal joints have a fibrous capsule, strengthened by palmar and collateral ligaments

Proximal phalanx

Second metacarpophalangeal joint
These joints allow about 90 degrees of flexion, a very small amount of extension, and about 30 degrees of abduction and adduction of the metacarpals

First metacarpophalangeal joint
Allows about 60 degrees of flexion, a little extension, as well as abduction and adduction

Collateral ligament

First metacarpal
The shortest and thickest of the metacarpals

Fifth metacarpal

First carpometacarpal joint
The first metacarpal lies at right angles to the metacarpals of the fingers, so that flexion and extension of the thumb occur in the same plane as abduction and adduction of the fingers

Dorsal carpometacarpal ligament

Hamate

Capitate

Triquetrum

Dorsal intercarpal ligament

Dorsal radiocarpal ligament

Styloid process of radius

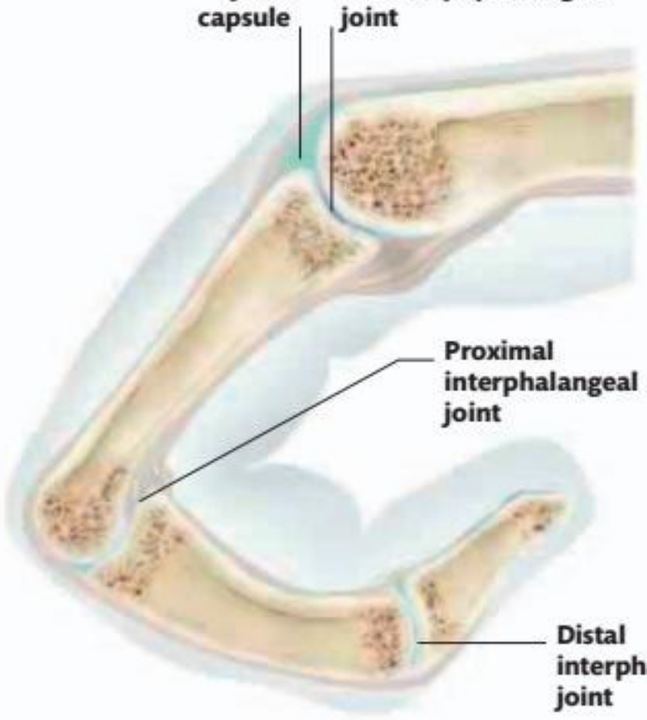
Styloid process of ulna

Scaphoid

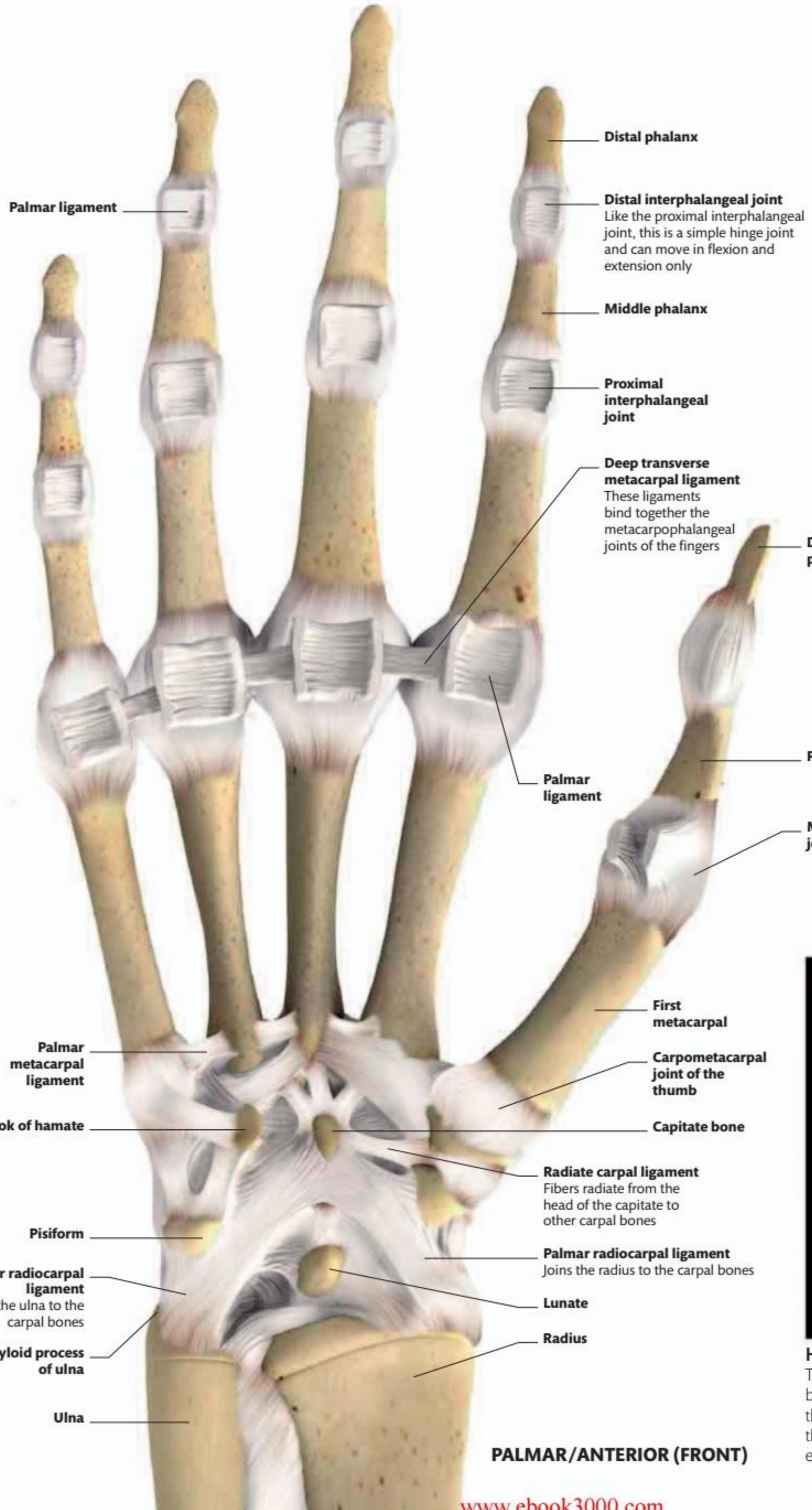
Radius

Ulna

DORSAL/POSTERIOR (BACK)



FINGER (SAGITTAL SECTION)



Hand X-ray
This X-ray of the hand clearly shows the carpal bones in the wrist and the joints between them. Near the metacarpophalangeal joint of the thumb, the thumb's tiny sesamoid bones, embedded in tendons, are also visible.

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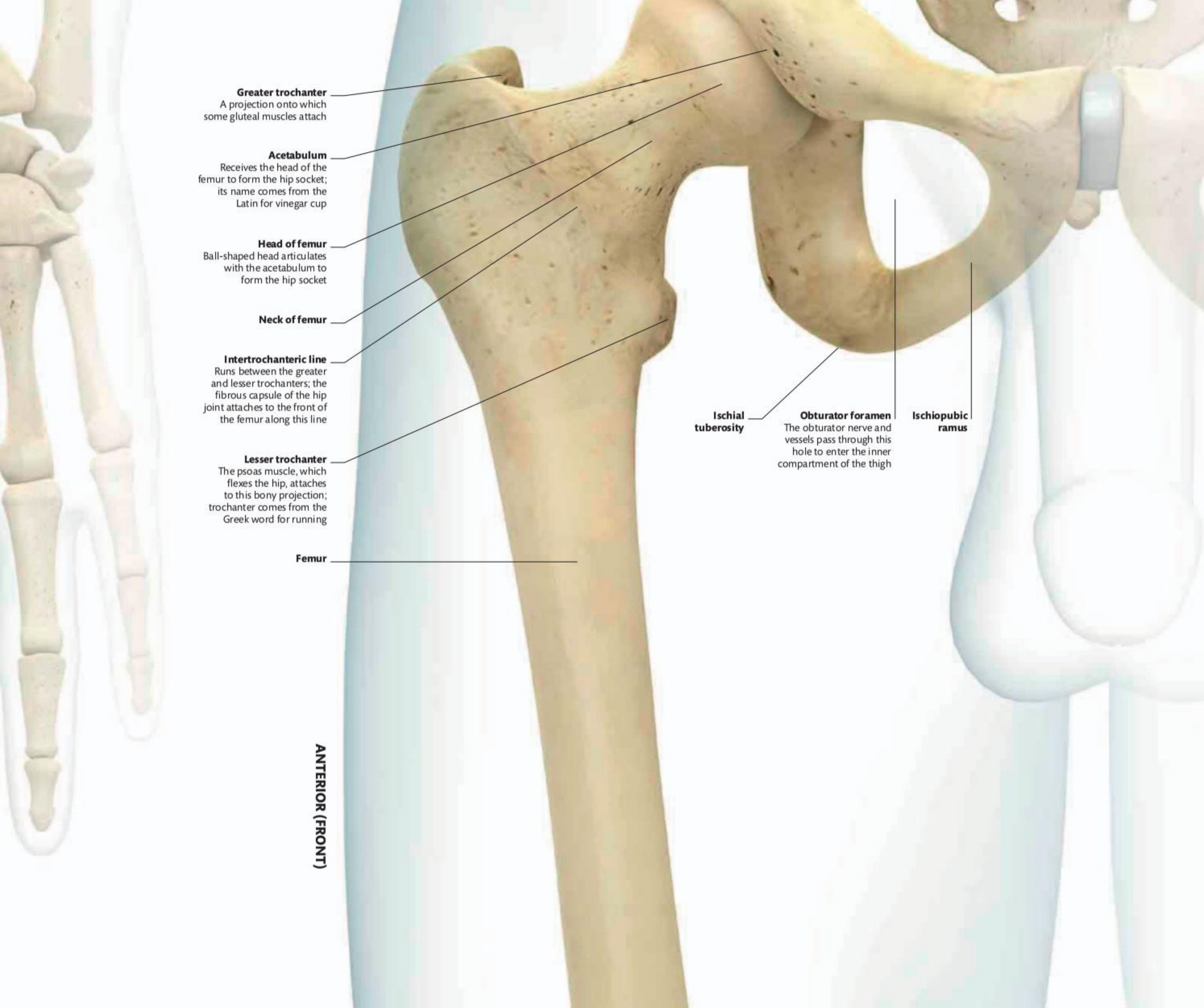
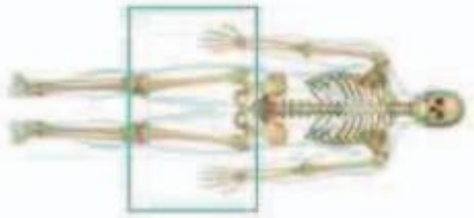

Greater trochanter
A projection onto which some gluteal muscles attach
Acetabulum
Receives the head of the femur to form the hip socket; its name comes from the Latin for vinegar cup
Head of femur
Ball-shaped head articulates with the acetabulum to form the hip socket
Neck of femur
Intertrochanteric line
Runs between the greater and lesser trochanters; the fibrous capsule of the hip joint attaches to the front of the femur along this line
Lesser trochanter
The psoas muscle, which flexes the hip, attaches to this bony projection; trochanter comes from the Greek word for running
Femur
Ischial tuberosity
Obturator foramen
The obturator nerve and vessels pass through this hole to enter the inner compartment of the thigh
Ischiopubic ramus
ANTERIOR (FRONT)

HIP AND THIGH



The leg or, to be anatomically precise, the lower limb, is attached to the spine by the pelvic bones. This is a much more stable arrangement than that of the shoulder girdle, which anchors the arm, because the legs and pelvis must bear our body weight as we stand or move around. The sacroiliac joint provides a strong attachment between the ilium of the pelvis and the sacrum, and the hip joint is a much deeper and more stable ball-and-socket joint than that in the shoulder. The neck of the femur joins the head at an obtuse angle. A slightly raised diagonal line on the front of the neck (the intertrochanteric line) shows where the fibrous capsule of the hip joint attaches to the bone.

Shaft of femur
This is not vertical, but angled inward slightly, to bring the knees under the body

Base of patella

Patellar surface of the femur

Lateral epicondyle
The term epicondyle (meaning close to the condyle) describes a projecting part of bone near a joint that provides a point of attachment for muscles

Lateral condyle of the femur
Condyle comes from the Greek word for knuckle; the term describes parts of the ends of bones that form joints

Apex of patella

Adductor tubercle
The point at which the tendon of adductor magnus attaches to the femur

Medial epicondyle

Patella
The technical name for the kneecap comes from the Latin for small dish

Medial condyle

Tibia

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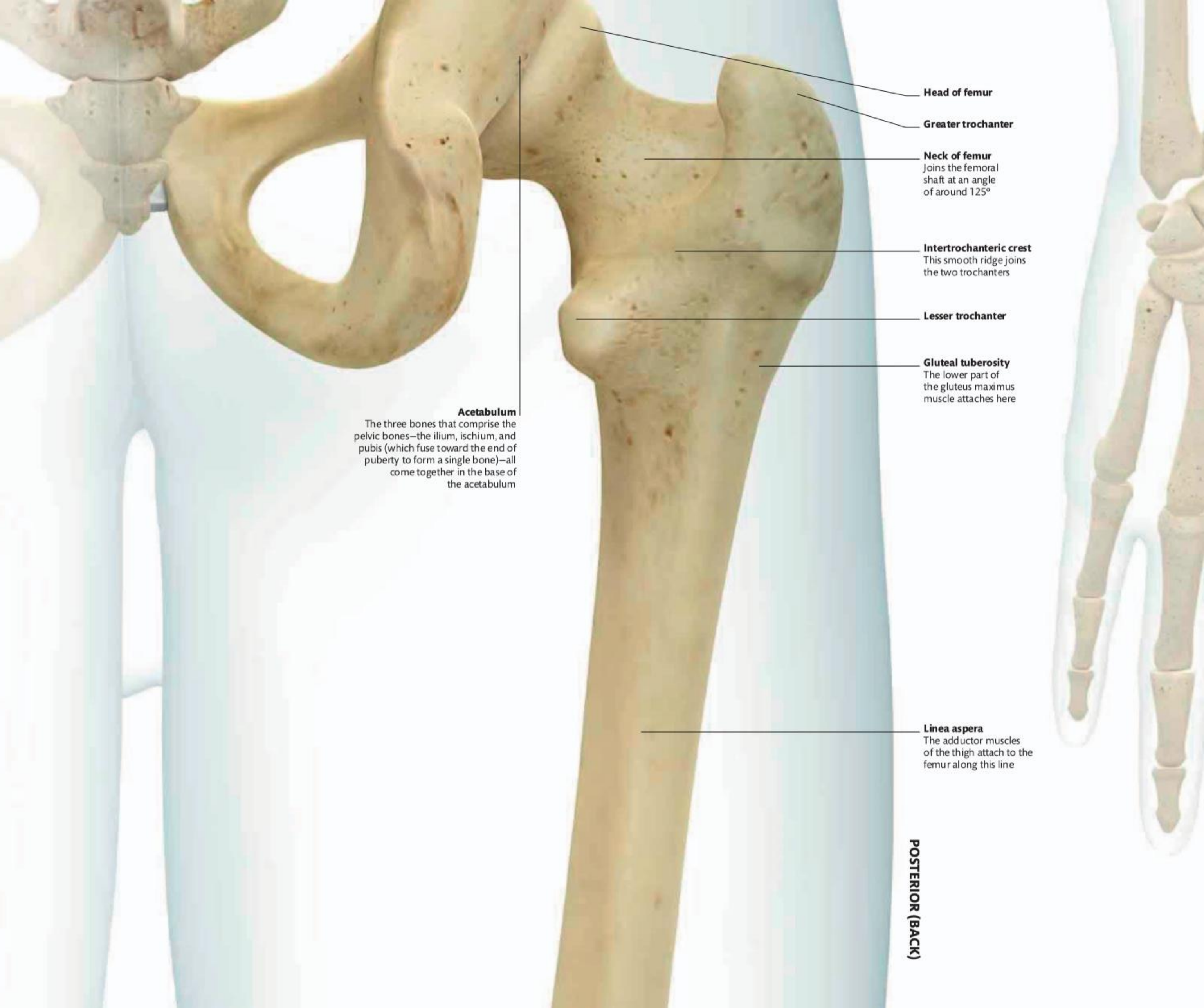
Head of femur
Greater trochanter
Neck of femur
Joins the femoral shaft at an angle of around 125°
Intertrochanteric crest
This smooth ridge joins the two trochanters
Lesser trochanter
Gluteal tuberosity
The lower part of the gluteus maximus muscle attaches here
Acetabulum
The three bones that comprise the pelvic bones—the ilium, ischium, and pubis (which fuse toward the end of puberty to form a single bone)—all come together in the base of the acetabulum
Linea aspera
The adductor muscles of the thigh attach to the femur along this line
POSTERIOR (BACK)

HIP AND THIGH

The shaft of the femur (thighbone) is cylindrical, with a marrow cavity. The linea aspera runs down along the back of the femoral shaft. This line is where the inner thigh's adductor muscles attach to the femur. Parts of the quadriceps muscle also wrap right around the back of the femur to attach to the linea aspera. At the bottom—or distal—end, toward the knee, the femur widens to form the knee joint with the tibia and the patella. From the back, the distal end of the femur has a distinct double-knuckle shape, with two condyles (rounded projections) that articulate with the tibia.

Lateral epicondyle

Intercondylar fossa
Cruciate ligaments attach to the femur in this depression between the condyles

Lateral condyle of femur
Articulates with the slightly concave lateral condyle of the tibia

Lateral condyle of tibia

Shaft of femur

Medial supracondylar line
The adductor magnus muscle attaches to the femur at the linea aspera and medial supracondylar line, all the way down to the adductor tubercle

Lateral supracondylar line

Popliteal surface
This smooth area forms the base of the popliteal fossa at the back of the knee

Adductor tubercle

Medial condyle of femur
Rests on the medial condyle of the tibia

Medial condyle of tibia

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HIP AND KNEE

The hip joint is very stable. Its fibrous capsule is strengthened by ligaments that attach from the neck of the femur to the pelvic bone. These are the iliofemoral and pubofemoral ligaments at the front and the ischiofemoral ligament at the back. Inside the joint capsule, a small ligament attaches from the edge of the acetabulum (hip socket) to the head of the femur. The knee joint is formed by the articulation of the femur with the tibia and patella. Although primarily a hinge joint, the knee also permits some rotation to occur. These complex movements are reflected by the complexity of the joint: there are crescent-shaped articular disks (menisci) inside the joint, powerful collateral ligaments on either side of the joint, as well as crossed-over cruciate ligaments binding the femur to the tibia, and numerous extra pockets of synovial fluid, called bursae, that lubricate tendons around the joint.

Ilium
Ilium, pubis, and ischium of the pelvis all meet in the acetabulum or hip socket

Tendon of rectus femoris
Attaches to the anterior inferior iliac spine

Pubofemoral ligament
Blends with the inner side of the hip capsule

Iliofemoral ligament
This strong ligament strengthens the front of the fibrous capsule of the hip joint

Superior pubic ramus
Forms the upper border of the obturator foramen

Greater trochanter of femur

Body of pubic bone

Ischiopubic ramus
Forms the lower border of the obturator foramen

Obturator membrane
Covers over the obturator foramen, leaving just a small gap at the top where the obturator nerve and vessels pass out of the pelvis into the thigh

Ischium

Ischial tuberosity
Hamstring muscles of the thigh attach here

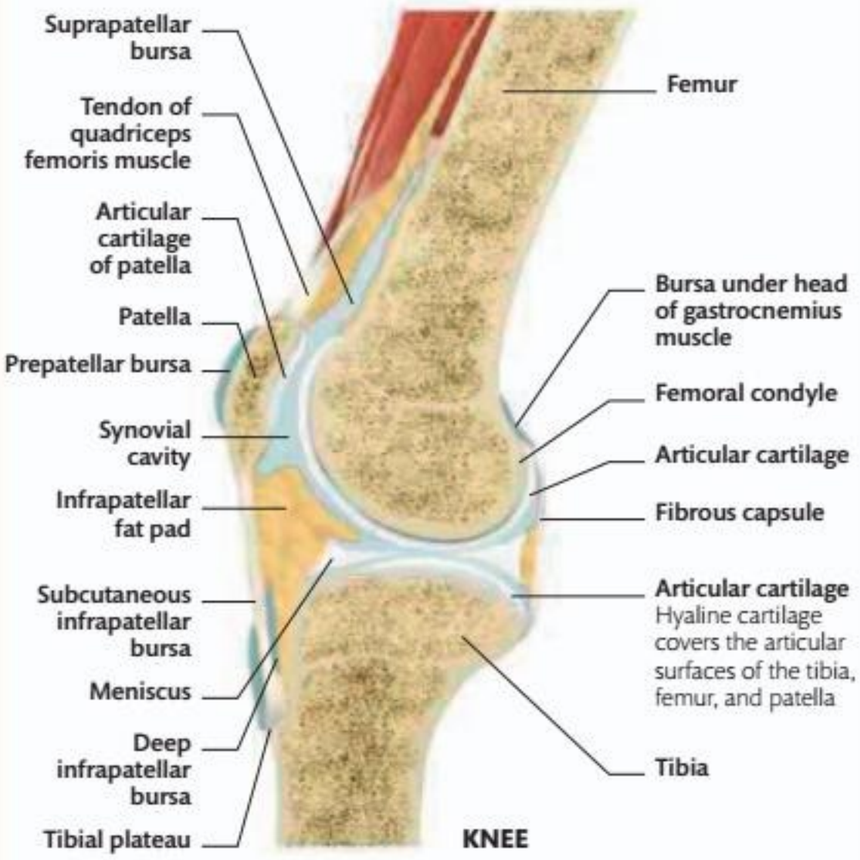
Intertrochanteric line of the femur
The iliofemoral ligament attaches to the femur along this line

Lesser trochanter of femur

HIP (ANTERIOR/FRONT)

SYNOVIAL JOINTS

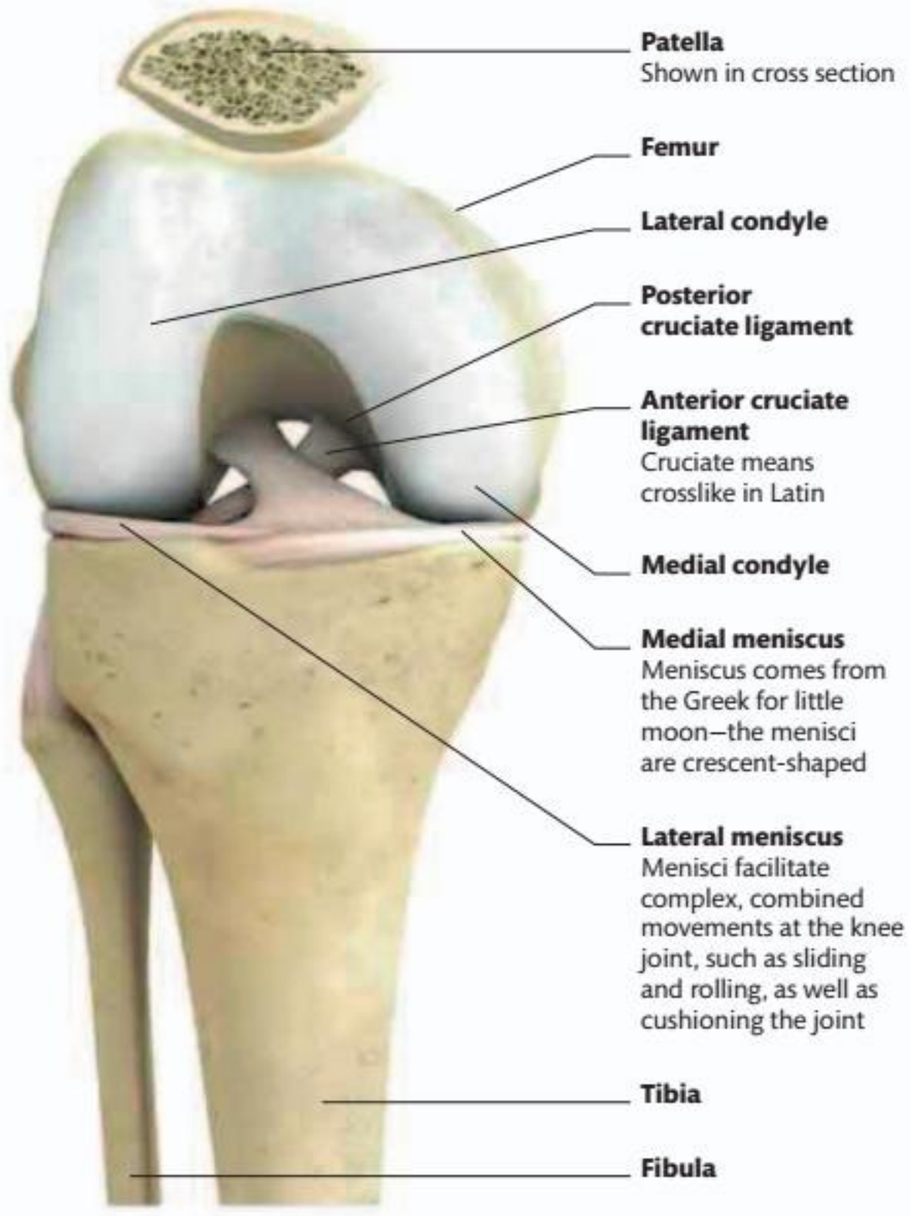
The majority of the body's 320 or so joints, including those in the finger, knee, and shoulder, are free-moving synovial joints. The joint surfaces are lined with smooth hyaline cartilage to reduce friction, and contain lubricating synovial fluid.



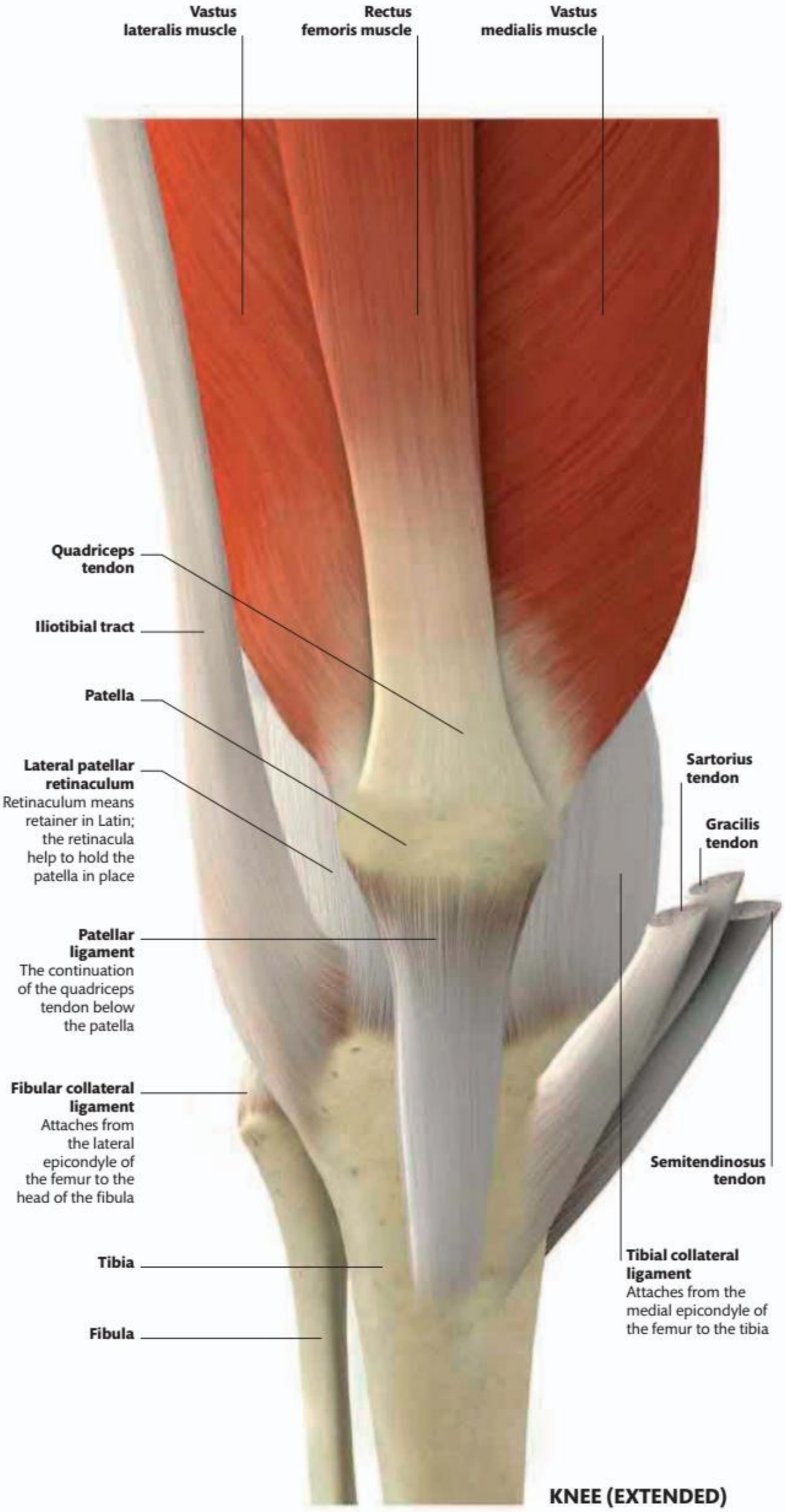
KNEE

Complex joint

A complex synovial joint, such as the knee, has articular discs or menisci inside the synovial cavity. The knee is also a compound hinge joint, as it involves more than two bones. Its complex anatomy allows it to move in flexion and extension, but some sliding and axial rotation of the femur on the tibia also occurs.



KNEE (FLEXED)



KNEE (EXTENDED)

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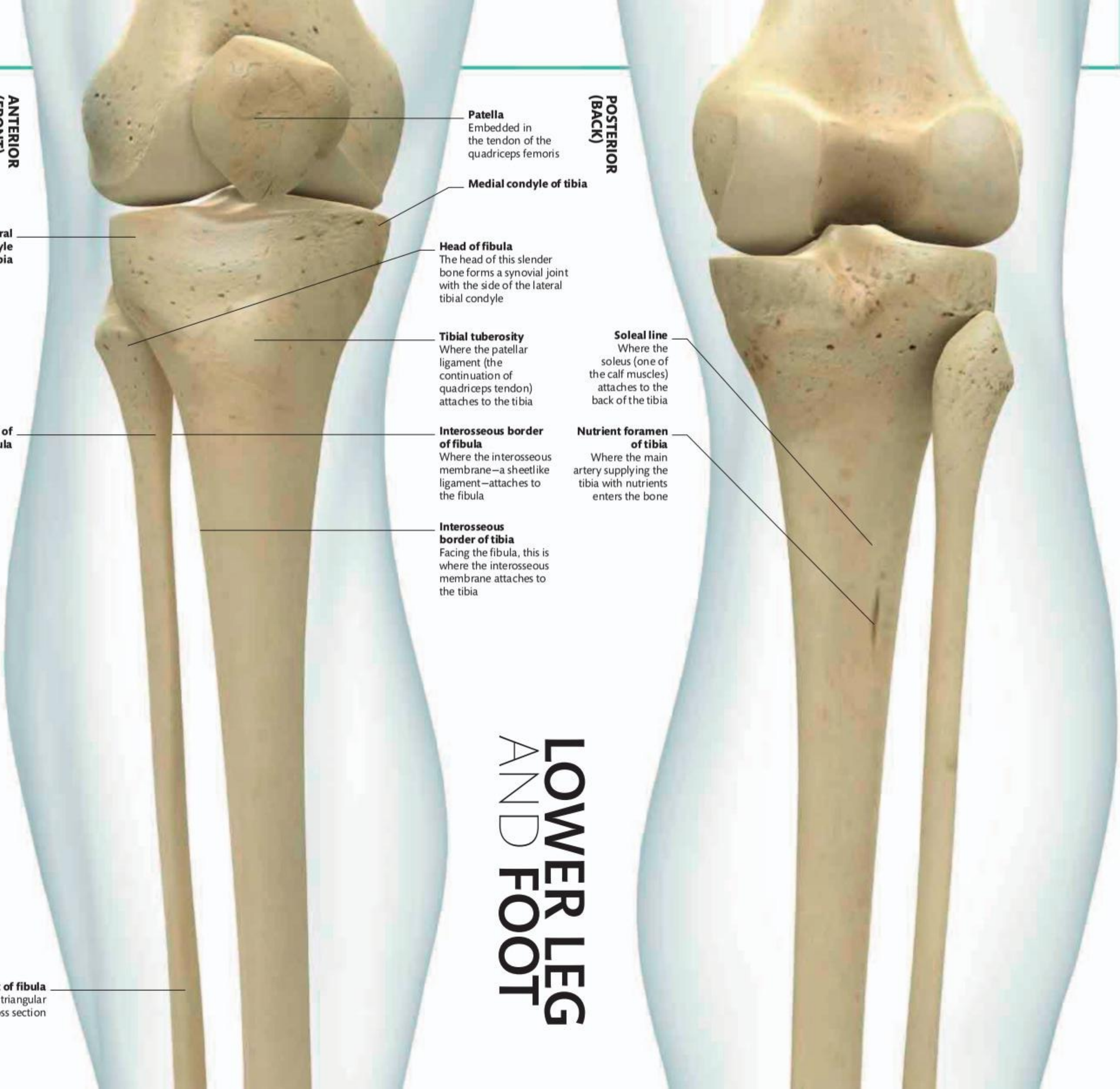
LOWER LEG AND FOOT

ANTERIOR (FRONT)

POSTERIOR (BACK)



Patella
Embedded in the tendon of the quadriceps femoris

Medial condyle of tibia

Lateral condyle of tibia

Head of fibula
The head of this slender bone forms a synovial joint with the side of the lateral tibial condyle

Tibial tuberosity
Where the patellar ligament (the continuation of quadriceps tendon) attaches to the tibia

Soleal line
Where the soleus (one of the calf muscles) attaches to the back of the tibia

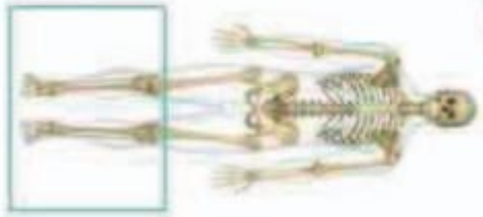
Neck of fibula

Interosseous border of fibula
Where the interosseous membrane—a sheetlike ligament—attaches to the fibula

Nutrient foramen of tibia
Where the main artery supplying the tibia with nutrients enters the bone

Interosseous border of tibia
Facing the fibula, this is where the interosseous membrane attaches to the tibia

Shaft of fibula
Roughly triangular in cross section



The tibia is the main weight-bearing bone of the lower leg. The fibula, which attaches to the tibia below the knee joint, provides extra areas for the attachment of muscles in the shin and calf and also forms part of the ankle joint. The foot comprises the tarsal bones, metatarsals, and phalanges. The arrangement of these bones is very similar to that of the carpals, metacarpals, and phalanges in the hand. In fact, each limb can be seen to be constructed to a common plan, with a limb girdle providing attachment to the thorax or spine, a single long bone in the first segment, two long bones in the second, a collection of small bones (at the wrist or ankle), and a fan of long, slender bones forming fingers or toes.

Medial surface of tibia
This smooth surface lies just below the skin in the shin

Anterior border
This sharp edge can be easily felt on the front of the shin

Shaft of tibia
Like the fibula, this is triangular in section

Talus
Meaning ankle bone in Latin, the talus is the uppermost of seven tarsals and forms part of the ankle joint

Navicular
With a name that means boat-shaped, this bone is shaped a bit like a small coracle

Cuboid
A roughly cube-shaped tarsal

Lateral cuneiform
Cuneiform means wedge-shaped in Latin; this is the outermost of the three cuneiform bones in the foot

Fifth metatarsal
Five long metatarsal bones attach the tarsals to the phalanges, or toe bones

Proximal phalanx
The second to fifth toes each have three phalanges: proximal, middle, and distal

Middle phalanx

Distal phalanx

Medial malleolus

Intermediate cuneiform

Medial cuneiform

First metatarsal

Proximal phalanx
Phalanx comes from a Greek word for a line of infantry, and it refers to both the finger and toe bones; the big toe has just two phalanges: proximal and distal

Distal phalanx

Shaft of fibula
The shaft of the fibula contains a marrow cavity

Shaft of tibia
This also contains a marrow cavity

Medial malleolus
Malleolus means small hammer in Latin; the medial malleolus is part of the tibia, and articulates with the medial, or inner, surface of the talus

Lateral malleolus
The expanded lower end of the fibula, articulating with the lateral, or outer, side of the talus

Talus

Calcaneus
Meaning heel bone in Latin, this is the largest tarsal bone, projecting posteriorly to form a lever to which the Achilles tendon attaches

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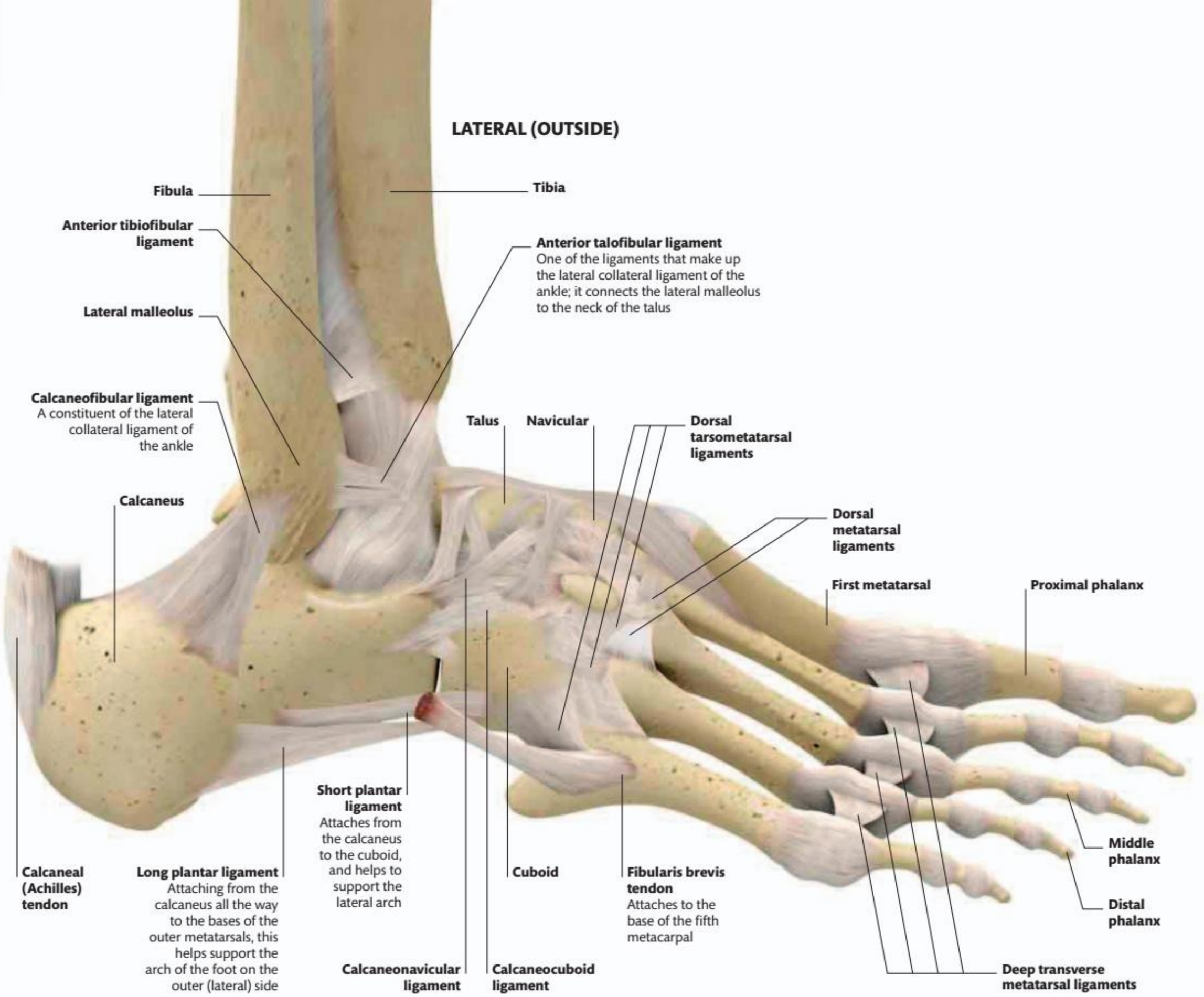


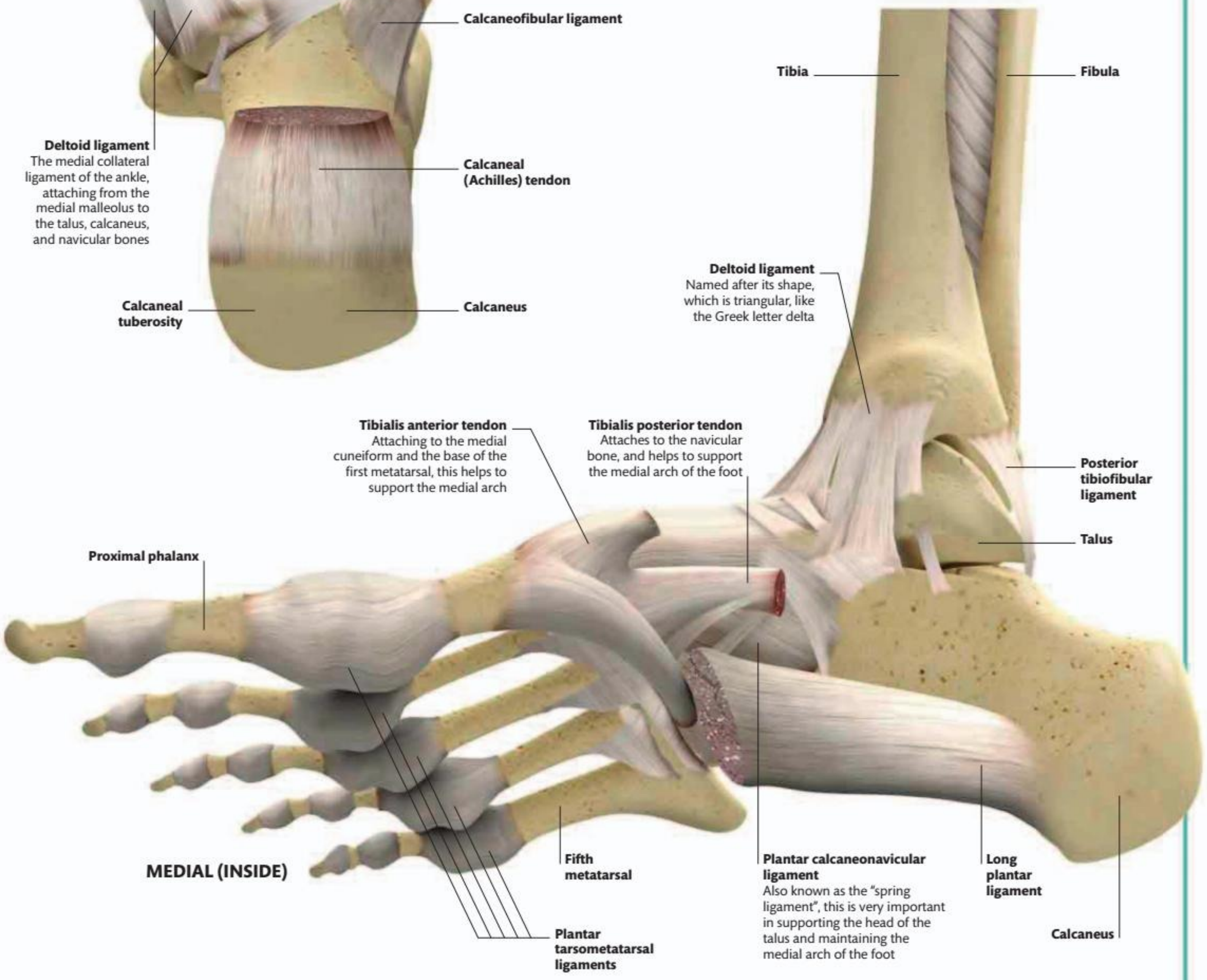
X-ray on tiptoe
This X-ray shows the foot in action. The calf muscles are pulling up on the lever of the calcaneus to flex the ankle down (plantarflex), while the metatarsophalangeal joints are extended.

FOOT AND ANKLE

The ankle joint is a simple hinge joint. The lower ends of the tibia and fibula are firmly bound together by ligaments, forming a strong fibrous joint, and making a wrench shape that neatly sits around the nut of the talus. The joint is stabilized by strong collateral ligaments on either side. The talus forms synovial joints (see p.61) with the calcaneus beneath it, and the navicular bone in front of it. Level with the joint between the talus and the navicular is a joint between the calcaneus and the cuboid. These joints together allow the foot to be angled inward or outward—these movements are called inversion and eversion respectively. The skeleton of the foot is a sprung structure, with the bones forming arches, held together by ligaments and also supported by tendons.

POSTERIOR (BACK)

Top view of the foot bones
This is a dorsal-plantar X-ray of the foot, showing the bones as if you were looking down at your right foot. The two small bones near the head of the first metatarsal are sesamoid bones, embedded in the tendons of the short muscles operating the big toe.



MEDIAL (INSIDE)

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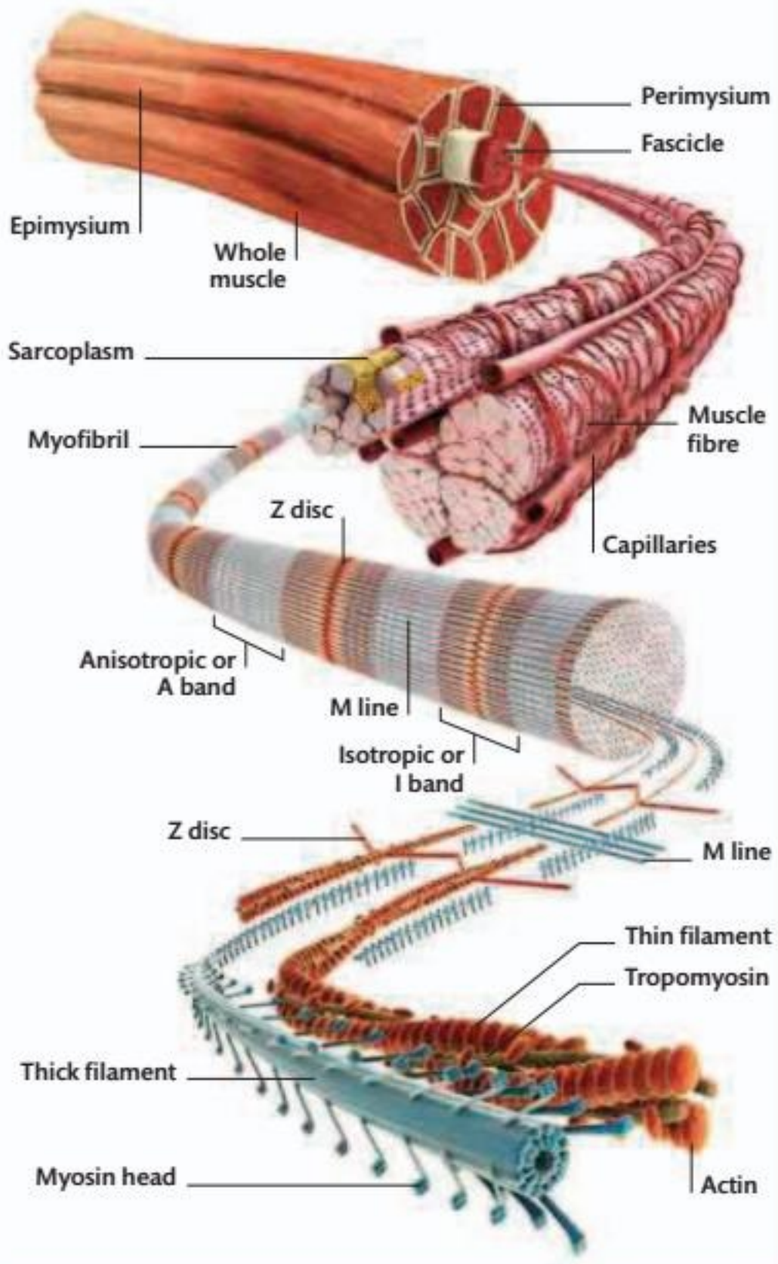
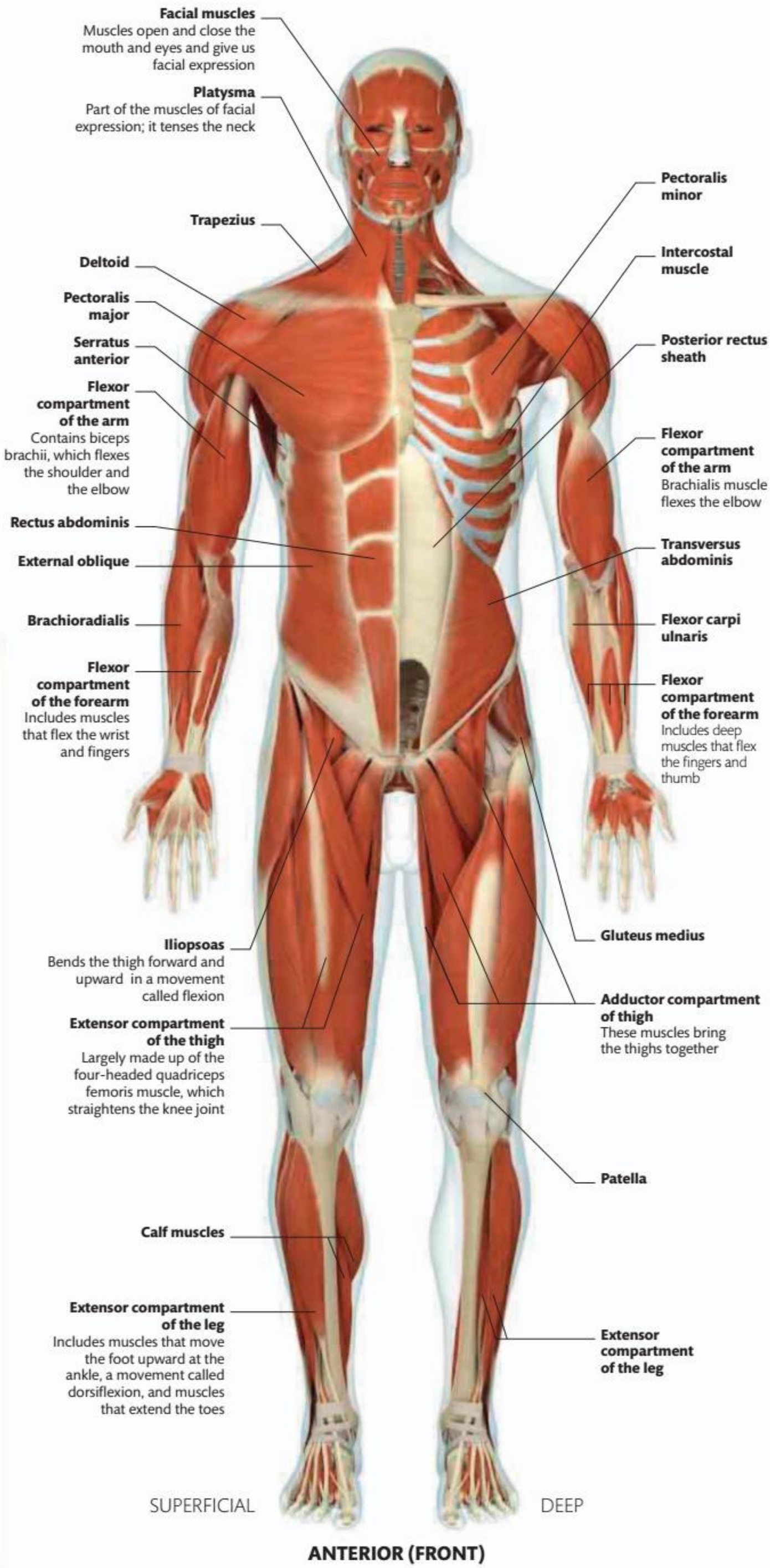
MUSCULAR SYSTEM **OVERVIEW**

There are three types of muscle in the body: skeletal, smooth, and cardiac. The main role of skeletal muscles is to generate movement. A muscle's movement, or "action" is produced when it contracts. The force it generates depends on the shape of the muscle. For instance, long, thin muscles contract a lot but exert low forces. Muscles attach to the skeleton by means of tendons, aponeuroses, and connective tissue called fascia. While muscles are well supplied with blood vessels and appear reddish, tendons have a sparse vascular supply and look white. The muscles in our body are located at varied depths. The deep layer sits closest to the bone, while the superficial one lies beneath the skin.

SKELETAL MUSCLE STRUCTURE

Skeletal muscle includes familiar muscles such as biceps or quadriceps. It is built up of parallel bundles of muscle fibers, which are conglomerations of many cells. These muscles are supplied by somatic motor nerves, which are part of the peripheral nervous system and are generally under conscious control.





Occipital belly of occipitofrontalis
Stretches from the frontal bone to the occipital bone at the back of the skull

Rhomboid muscles

Serratus anterior

Serratus posterior inferior

Trapezius

Deltoid

Short scapular muscles

Latissimus dorsi

Extensor compartment of the arm

Erector spinae
This muscle group, as its name suggests, helps to keep the spine erect

Transversus abdominis
The innermost of three sheet-like anterolateral (front-side) abdominal muscles

Extensor compartment of the forearm
Includes deep muscles that extend the thumb or move it out to the side

Extensor compartment of the arm
Contains one muscle, the triceps, which means three-headed; here we can see the two superficial parts of the muscle, the long and lateral heads

Extensor compartment of the forearm
Includes muscles that extend the wrist and fingers

Piriformis

Gluteus maximus
The word gluteus comes from the Greek for rump or buttock; maximus means the greatest in Latin

Flexor compartment of the thigh
These muscles bend or flex the knee; also known as the hamstrings

Flexor compartment of the thigh

Flexor compartment of the leg
Deep muscles that move the foot downward at the ankle (plantarflexion), and that flex or curl the toes

Fibular (peroneal) muscles
Two muscles that evert the foot (move it outward), named after the fibula bone in the lower leg

Flexor compartment of the leg
The most superficial muscle here is gastrocnemius; the name comes from the Greek word for calf, translating literally as the belly of the calf

DEEP SUPERFICIAL

POSTERIOR (BACK)

Temporalis

Brachialis

Deltoid

Short scapular muscles
Problems with these muscles can lead to osteoarthritis at the shoulder joint

Serratus anterior
Anchors the scapula against the chest wall and also helps to move it

Transversus abdominis

Erector spinae

Flexor compartment of the forearm
Some of these muscles originate from the medial epicondyle of the humerus

Gluteus maximus

Quadriceps femoris
Largest muscle in the extensor compartment of the thigh

Flexor compartment of the thigh
Hamstring injuries are common in athletes: the long muscles in this compartment stretch across two joints—the hip and the knee—and are at risk of tearing if overstretched

Flexor compartment of the leg
These muscles combine to form the Achilles tendon, which can be ruptured if overstretched in a sporting injury

Extensor compartment of the leg
The bony attachments of these muscles can become inflamed and painful in the condition "shin splints"

Achilles tendon

SIDE

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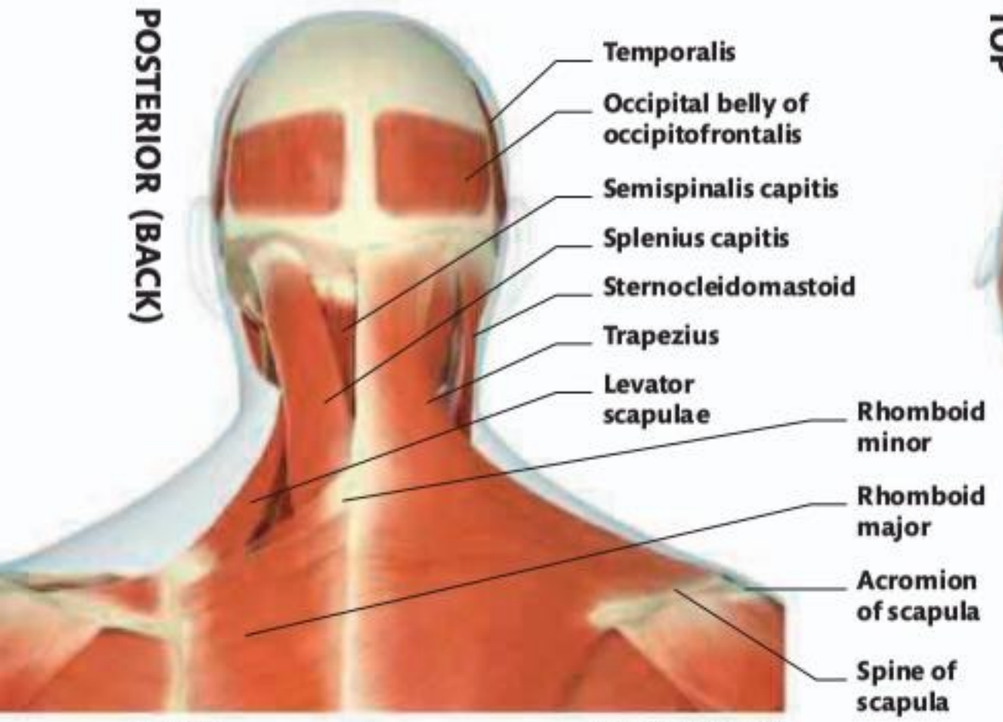
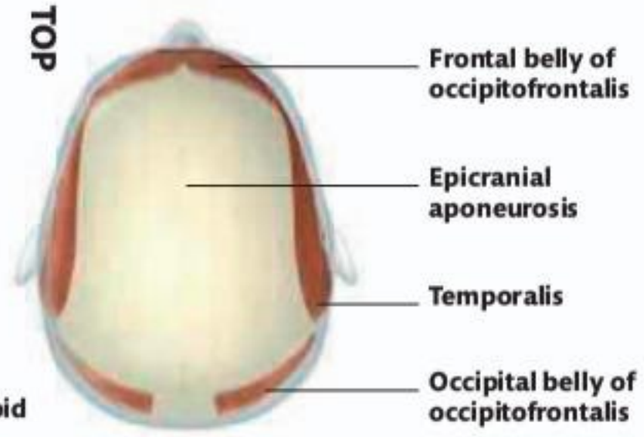
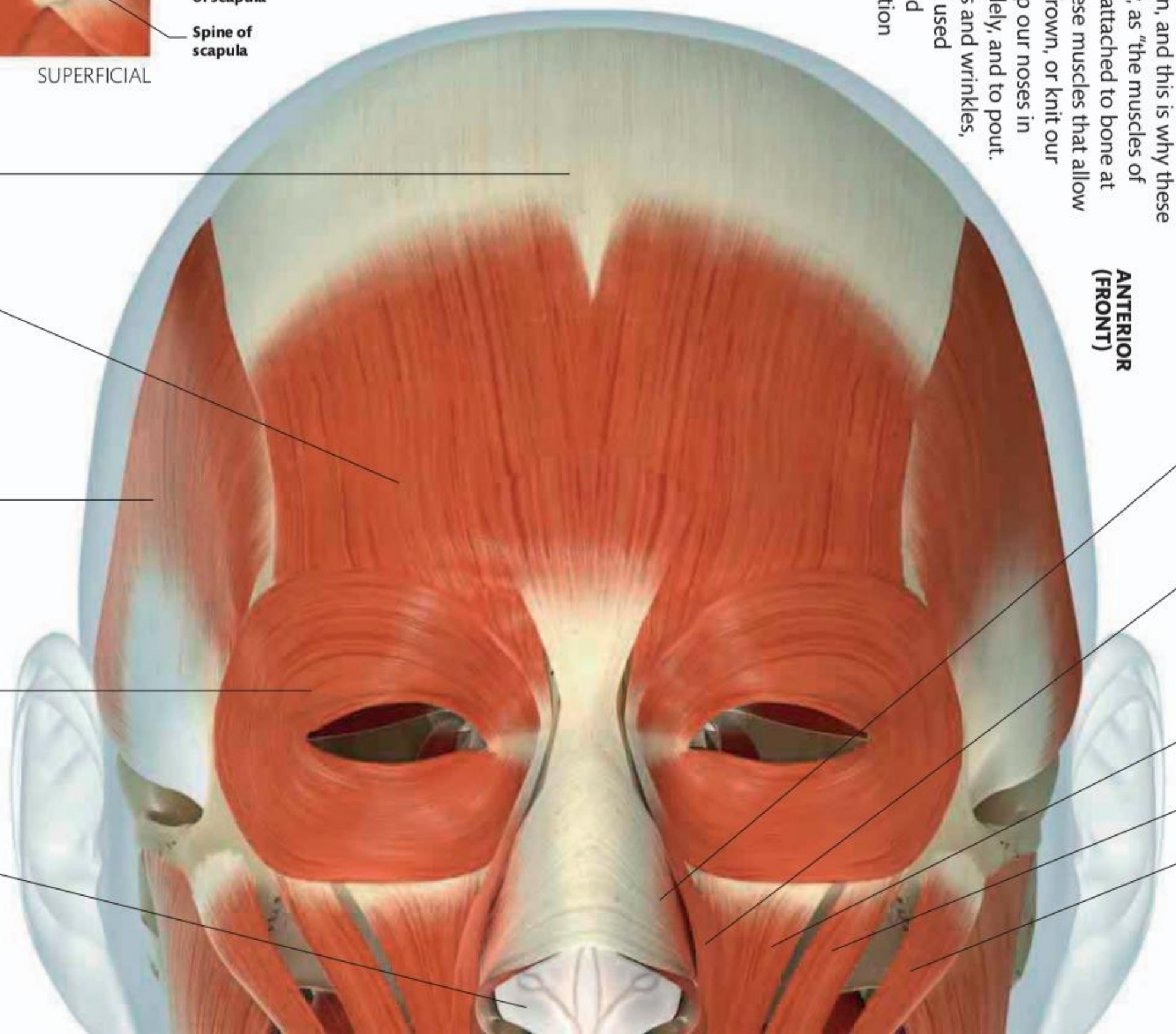
HEAD AND NECK

The muscles of the face have very important functions. They open and close the apertures in our faces—our eyes, noses, and mouths. But they also play an extremely important role in communication, and this is why these muscles are often known, collectively, as "the muscles of facial expression". These muscles are attached to bone at one end and skin at the other. It is these muscles that allow us to raise our eyebrows in surprise, frown, or knit our brows in concentration, to scrunch up our noses in distaste, to smile gently or to grin widely, and to pout. As we age, and our skin forms creases and wrinkles, these reflect the expressions we have used throughout our lives. The wrinkles and creases lie perpendicular to the direction of the underlying muscle fibers.







Epicranial aponeurosis
This connects the frontal and occipital bellies of the occipitofrontalis muscle

Frontal belly of occipitofrontalis
Occipitofrontalis extends from the eyebrows to the superior nuchal line on the back of the skull, and can raise the eyebrows and move the scalp

Temporalis
One of the four paired muscles of mastication, or chewing; acts to close the mouth and bring the teeth together

Orbicularis oculi
These muscle fibers encircle the eye and act to close the eye

Cartilage of the external nose

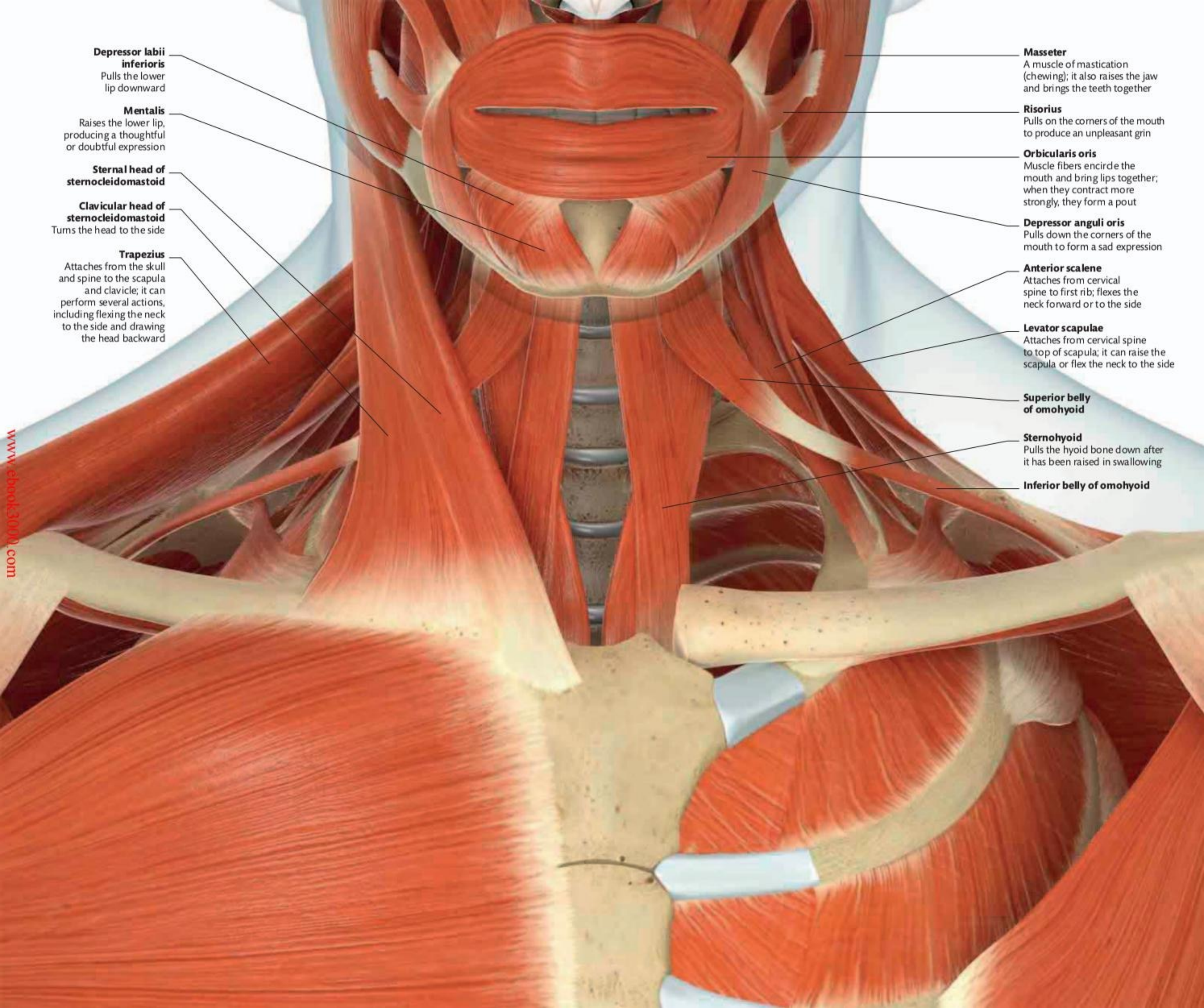
Nasalis
The upper part of this nasal muscle compresses the nose, while the lower part flares the nostrils

Levator labii superioris alaeque nasi
This small muscle with a very long name lifts the upper lip and the side of the nostril to produce an unpleasant sneer

Levator labii superioris
Raises the upper lip

Zygomaticus minor

Zygomaticus major
Both the zygomaticus major and minor attach from the zygomatic arch (cheek bone) to the side of the upper lip, and are used in smiling



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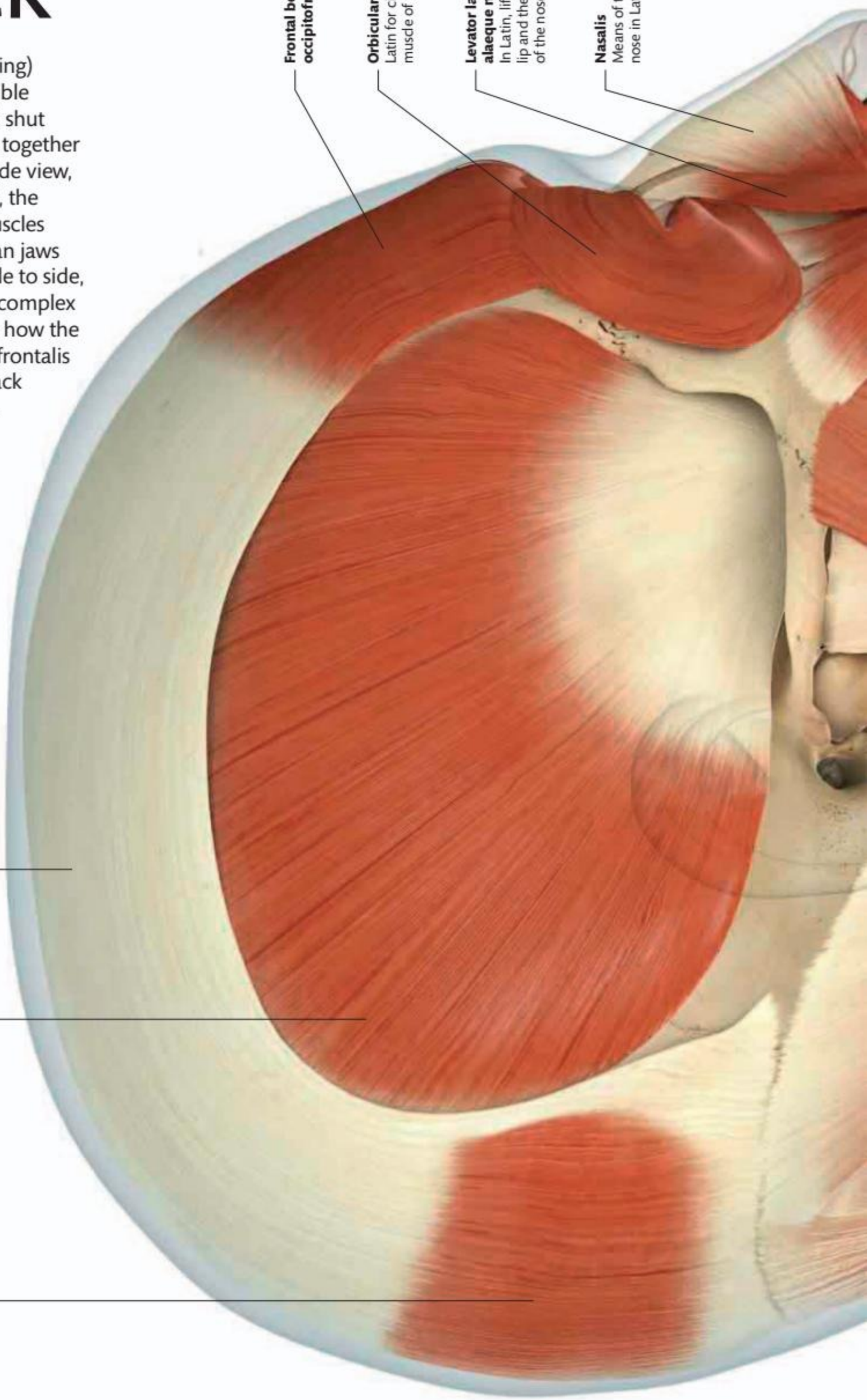
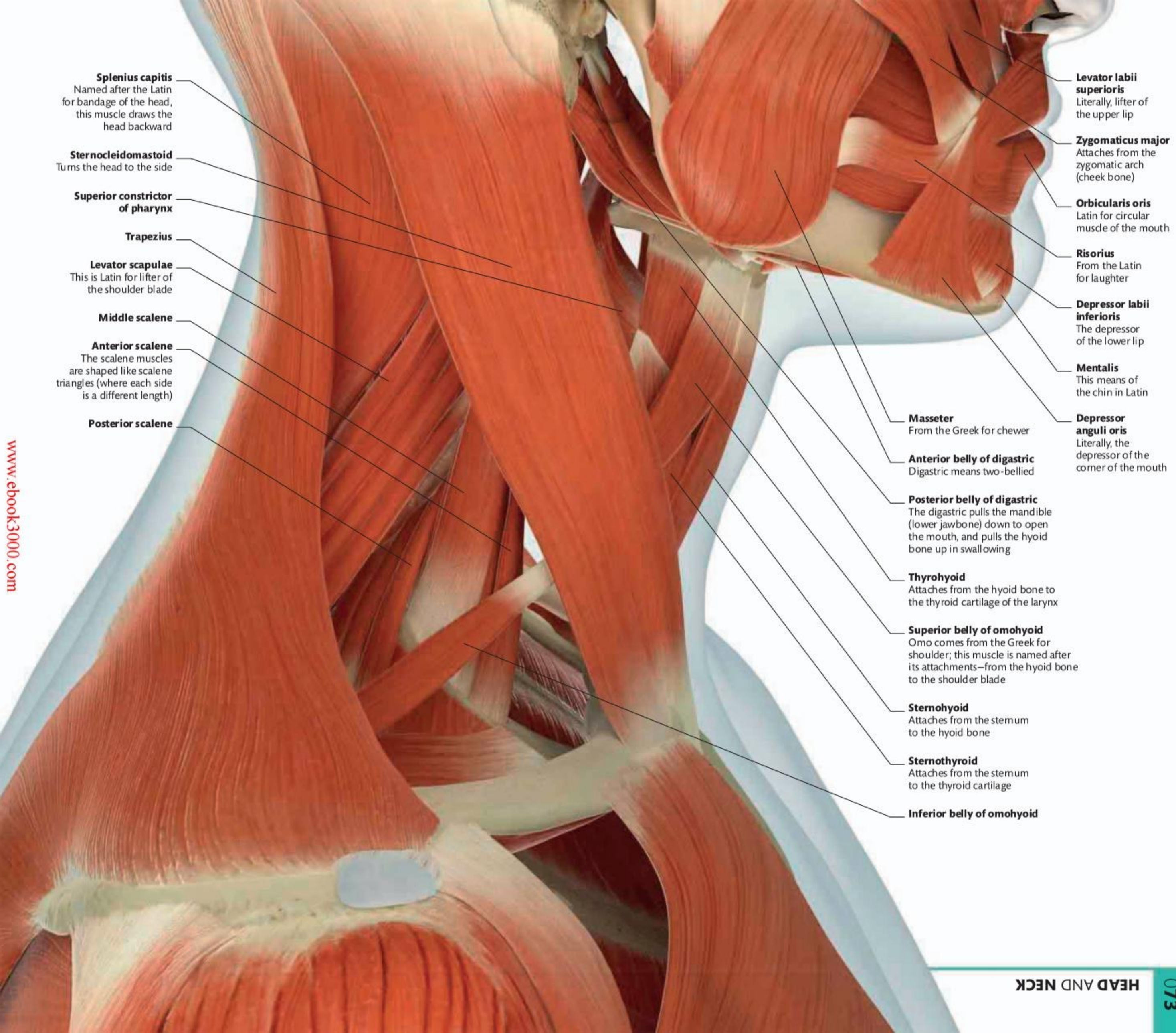
HEAD AND NECK

The muscles of mastication (chewing) attach from the skull to the mandible (jawbone), operating to open and shut the mouth, and to grind the teeth together to crush the food we eat. In this side view, we can see the two largest muscles of mastication, the temporalis and masseter muscles. Two smaller muscles attach to the inner surface of the mandible. Human jaws don't just open and close, they also move from side to side, and these four muscles act in concert to produce complex chewing movements. In this view, we can also see how the frontal bellies (fleshy central parts) of the occipitofrontalis muscle are connected to occipital bellies at the back of the head by a thin, flat tendon, or aponeurosis. This makes the entire scalp movable on the skull.



SIDE



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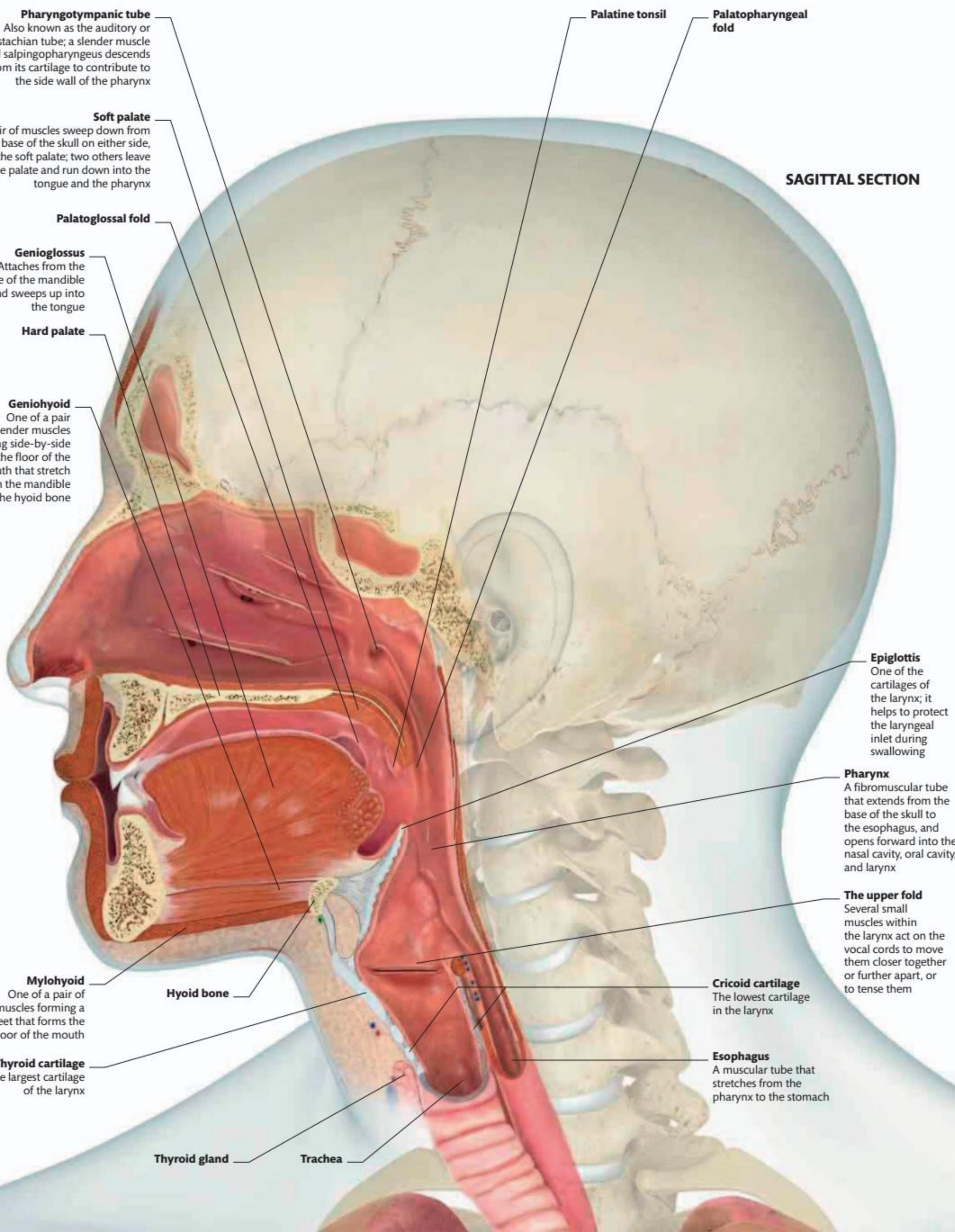


SAGITTAL SECTION

Pharyngotympanic tube
Also known as the auditory or Eustachian tube; a slender muscle called salpingopharyngeus descends from its cartilage to contribute to the side wall of the pharynx

Soft palate
A pair of muscles sweep down from the base of the skull on either side, into the soft palate; two others leave the palate and run down into the tongue and the pharynx

Palatoglossal fold

Genioglossus
Attaches from the inside of the mandible and sweeps up into the tongue

Hard palate

Geniohyoid
One of a pair of slender muscles lying side-by-side in the floor of the mouth that stretch from the mandible to the hyoid bone

Mylohyoid
One of a pair of muscles forming a sheet that forms the floor of the mouth

Hyoid bone

Thyroid cartilage
The largest cartilage of the larynx

Thyroid gland

Trachea

Palatine tonsil

Palatopharyngeal fold

Epiglottis
One of the cartilages of the larynx; it helps to protect the laryngeal inlet during swallowing

Pharynx
A fibromuscular tube that extends from the base of the skull to the esophagus, and opens forward into the nasal cavity, oral cavity, and larynx

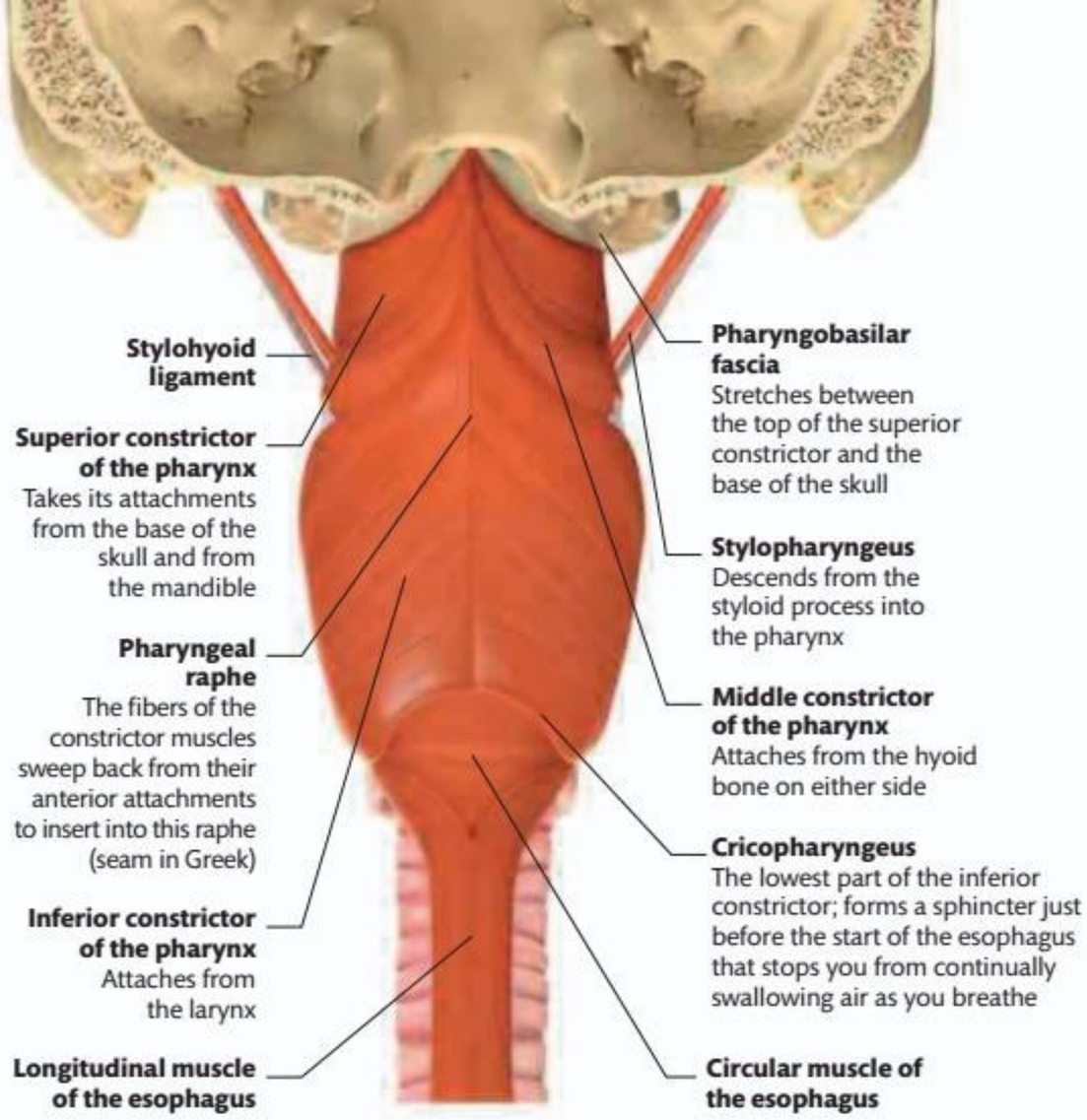
The upper fold
Several small muscles within the larynx act on the vocal cords to move them closer together or further apart, or to tense them

Cricoid cartilage
The lowest cartilage in the larynx

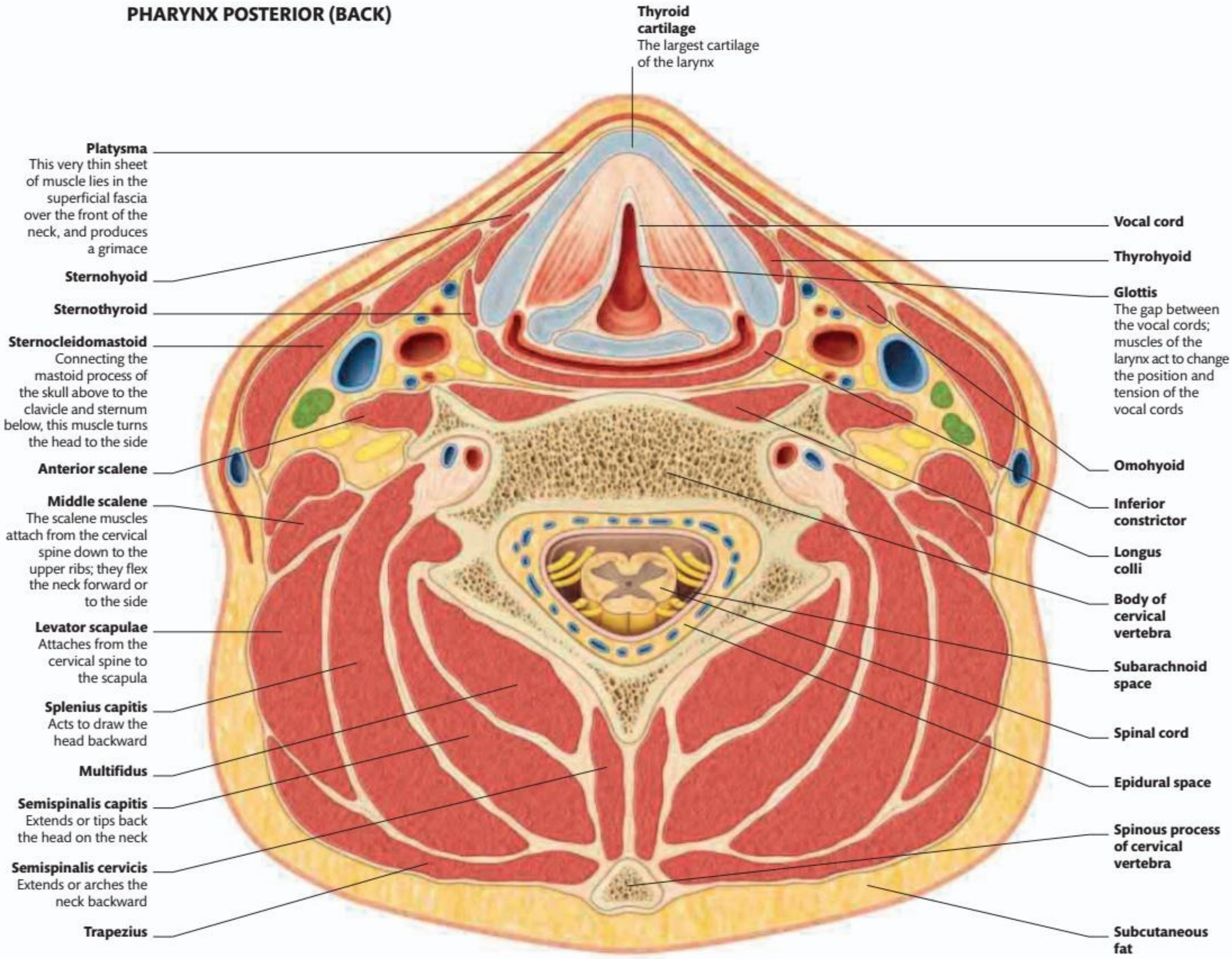
Esophagus
A muscular tube that stretches from the pharynx to the stomach

HEAD AND NECK

In the section through the head (opposite), we see the soft palate, tongue, pharynx, and larynx, all of which contain muscles. The soft palate comprises five pairs of muscles. When relaxed, it hangs down at the back of the mouth but, during swallowing, it thickens and is drawn upward to block off the airway. The tongue is a great mass of muscle, covered in mucosa. Some of its muscles arise from the hyoid bone and the mandible, and anchor it to these bones and move it around. Other muscle fibers are entirely within the tongue and change its shape. The pharyngeal muscles are important in swallowing, and the laryngeal muscles control the vocal cords. The muscles that move the eye can be seen on p.122.



PHARYNX POSTERIOR (BACK)



TRANSVERSE SECTION OF THE NECK AT THE VOCAL CORDS

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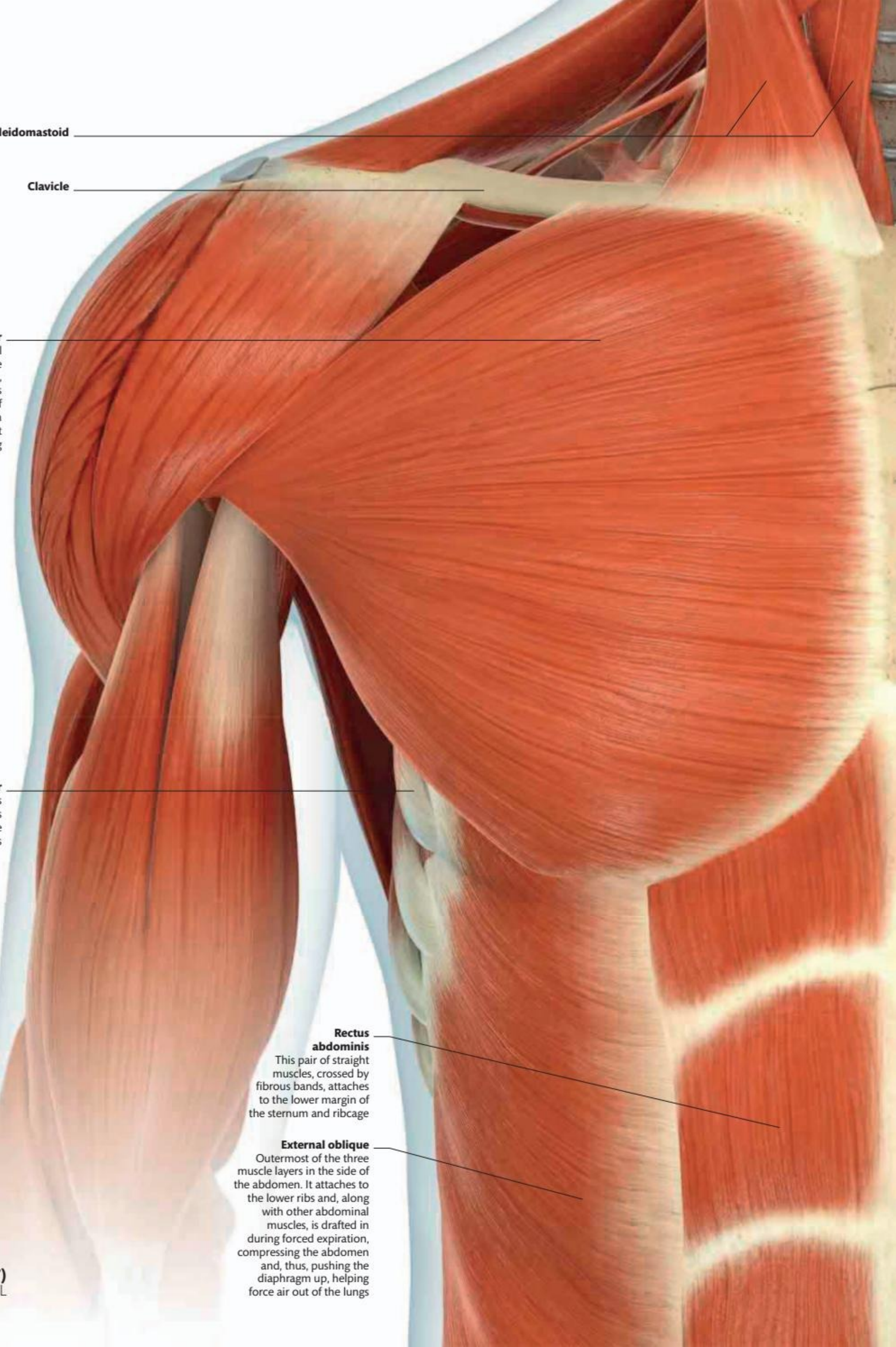

Sternocleidomastoid

Clavicle

Pectoralis major
This great pectoral muscle attaches to the clavicle, the sternum, and the ribs; it inserts into the upper part of the humerus. It can pull the ribs up and out during deep breathing

Serratus anterior
The digitations (fingerlike parts) of this muscle attach to the upper eight or nine ribs

Rectus abdominis
This pair of straight muscles, crossed by fibrous bands, attaches to the lower margin of the sternum and ribcage

External oblique
Outermost of the three muscle layers in the side of the abdomen. It attaches to the lower ribs and, along with other abdominal muscles, is drafted in during forced expiration, compressing the abdomen and, thus, pushing the diaphragm up, helping force air out of the lungs

ANTERIOR (FRONT)
SUPERFICIAL

Omohyoid

Scalenus anterior

Subclavius

Costal cartilage

Pectoralis minor

Sternum

Rib

Intercostal muscles
Three layers of muscle occupy the intercostal spaces between the ribs: external, internal, and innermost intercostal muscles

External intercostal muscle

Internal intercostal muscle
The muscle fibers of this middle layer run diagonally in the opposite direction to those of the external intercostal muscle

Posterior leaf of rectus sheath

Internal oblique

ANTERIOR (FRONT) DEEP

THORAX

The walls of the thorax are filled in, between the ribs, by the intercostal muscles. There are three layers of these muscles, and the muscle fibers of each layer lie in different directions. The main muscle for breathing is the diaphragm. Although the intercostal muscles are also active during respiration, their main job seems to be to prevent the spaces between the ribs from being "sucked in". Other muscles seen here may also be recruited to help with deep breathing. The sternocleidomastoid and scalene muscles in the neck can help by pulling the sternum and upper ribs upward. The pectoral muscles can also pull the ribs up and out, if the arm is held in a fixed position.

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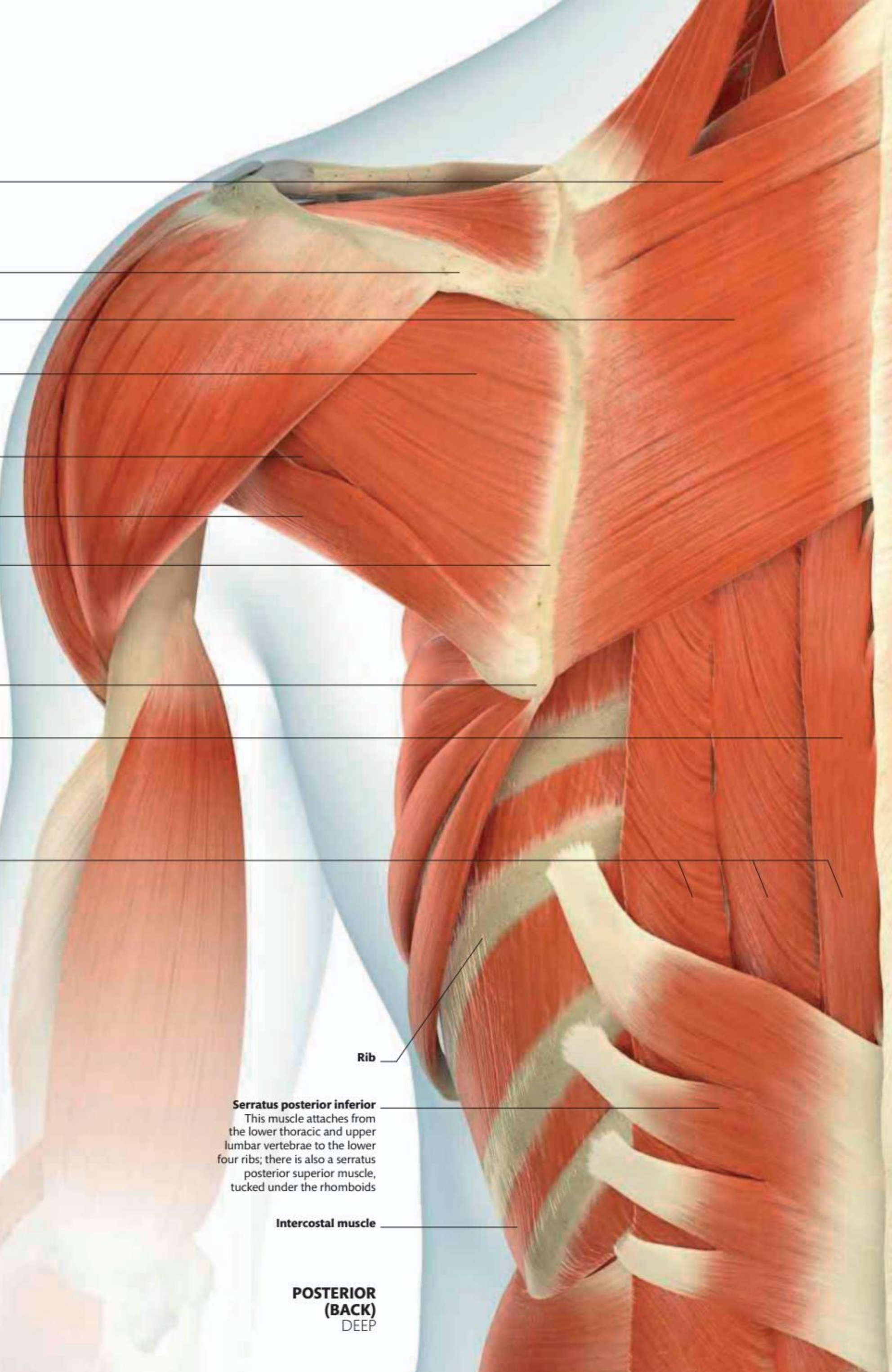
Rhomboid minor
The four-sided rhomboid muscles act to pull the scapulae toward the midline
Spine of scapula
Rhomboid major
Infraspinatus
One of the rotator cuff, or short scapular muscles
Teres minor
Teres major
Vertebral (medial) border of scapula
Inferior angle of scapula
Spinalis
The innermost (most medial) part of the erector spinae; it attaches to the spinous processes of the vertebrae
Erector spinae muscle group
Rib
Serratus posterior inferior
This muscle attaches from the lower thoracic and upper lumbar vertebrae to the lower four ribs; there is also a serratus posterior superior muscle, tucked under the rhomboids
Intercostal muscle
POSTERIOR (BACK)
DEEP

Trapezius

Infraspinatus

Teres major
This tapering muscle takes its name from the Latin for rounded off

Latissimus dorsi
This huge muscle sweeps up from the lower part of the back to attach to the humerus

External oblique

POSTERIOR (BACK)
SUPERFICIAL

THORAX

The superficial muscles of the back include two large, triangular-shaped muscles—the massive latissimus dorsi and trapezius muscles. Although latissimus dorsi is called into action during forced expiration, squeezing the lower chest to expel air, it is really a climbing muscle: if you hang by your arms, it is largely the powerful latissimus that can allow you to pull your body weight up. Underneath those superficial muscles are the deeper extensor muscles of the spine, which can be felt as a distinct ridge on each side of the spine, especially in the lumbar (lower back) region. The most bulky of these muscles are collectively known as erector spinae, and play a vital role doing just that—keeping the spine erect, or extending a flexed spine.

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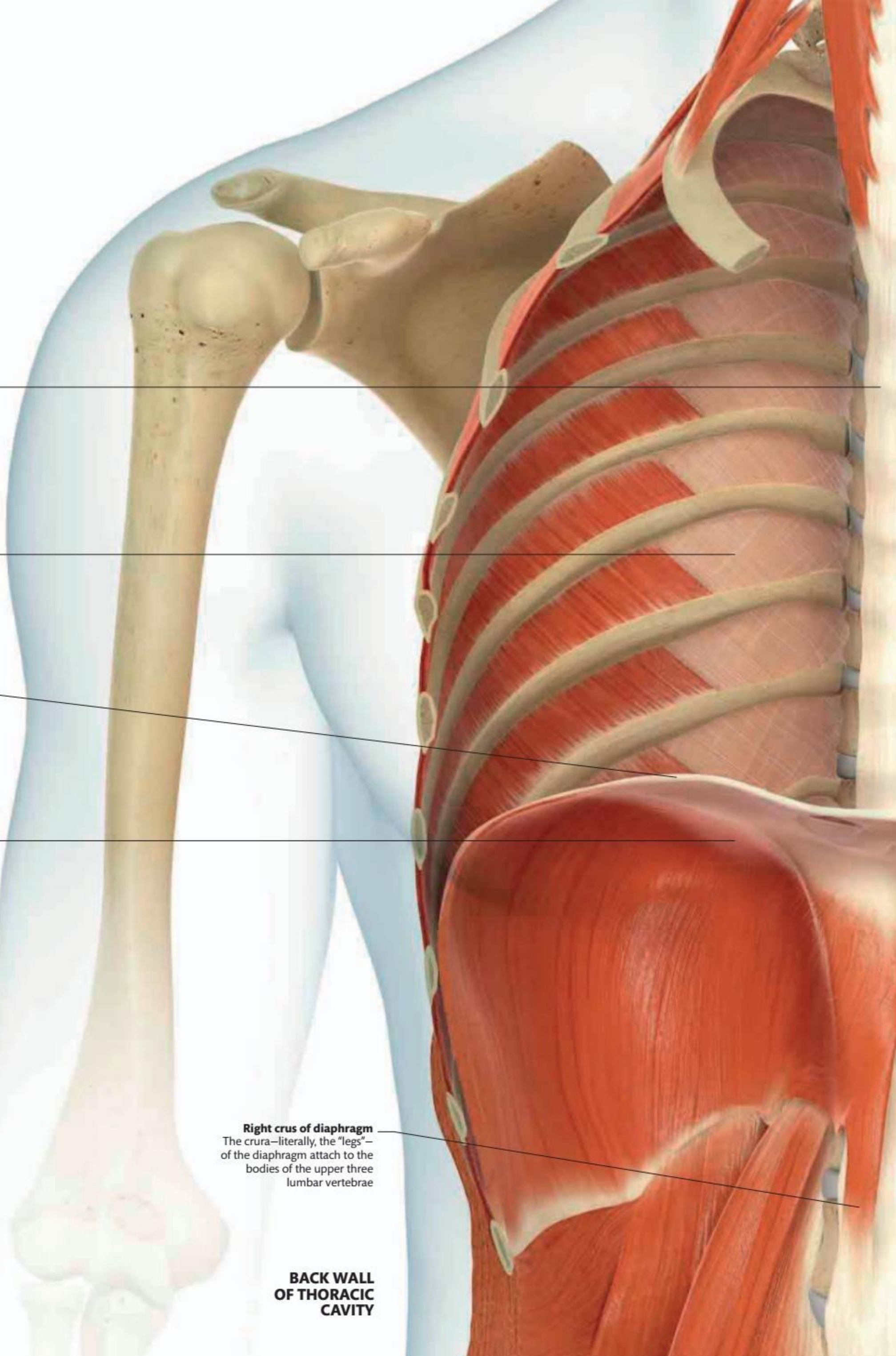

Anterior longitudinal ligament
Runs down and binds together the bodies of the vertebrae

Internal intercostal membrane
The internal intercostal muscles give way to a membrane at the back of the thorax

Central tendon of diaphragm
Flat tendon pierced by the inferior vena cava

Muscular part of diaphragm
Supplied by the phrenic nerves

Right crus of diaphragm
The crura—literally, the "legs"—of the diaphragm attach to the bodies of the upper three lumbar vertebrae

BACK WALL OF THORACIC CAVITY

Middle scalene

Anterior scalene

Longus colli

External intercostal muscle
These muscles are replaced by a membrane around the front of the thorax. (Seen here after removal of internal intercostal membrane)

Internal intercostal muscle
The intercostal muscles are supplied by intercostal nerves

Left crus of diaphragm

THORAX

The diaphragm, which divides the thorax and abdomen, is the main muscle of respiration. It attaches to the spine and to deep muscles in the back, around the margins of the rib cage, and to the sternum at the front. Its muscle fibers radiate out from a central, flat tendon to these attachments. The diaphragm contracts and flattens during inspiration, increasing the volume inside the chest cavity, and pulling air into the lungs; during expiration, it relaxes back into a domed shape. The intercostal muscles and diaphragm are "voluntary" muscle, and you can consciously control your breathing. But most of the time you don't have to think about breathing, since they work to a rhythm set by the brain stem, producing about 12 to 20 breaths per minute in an adult.

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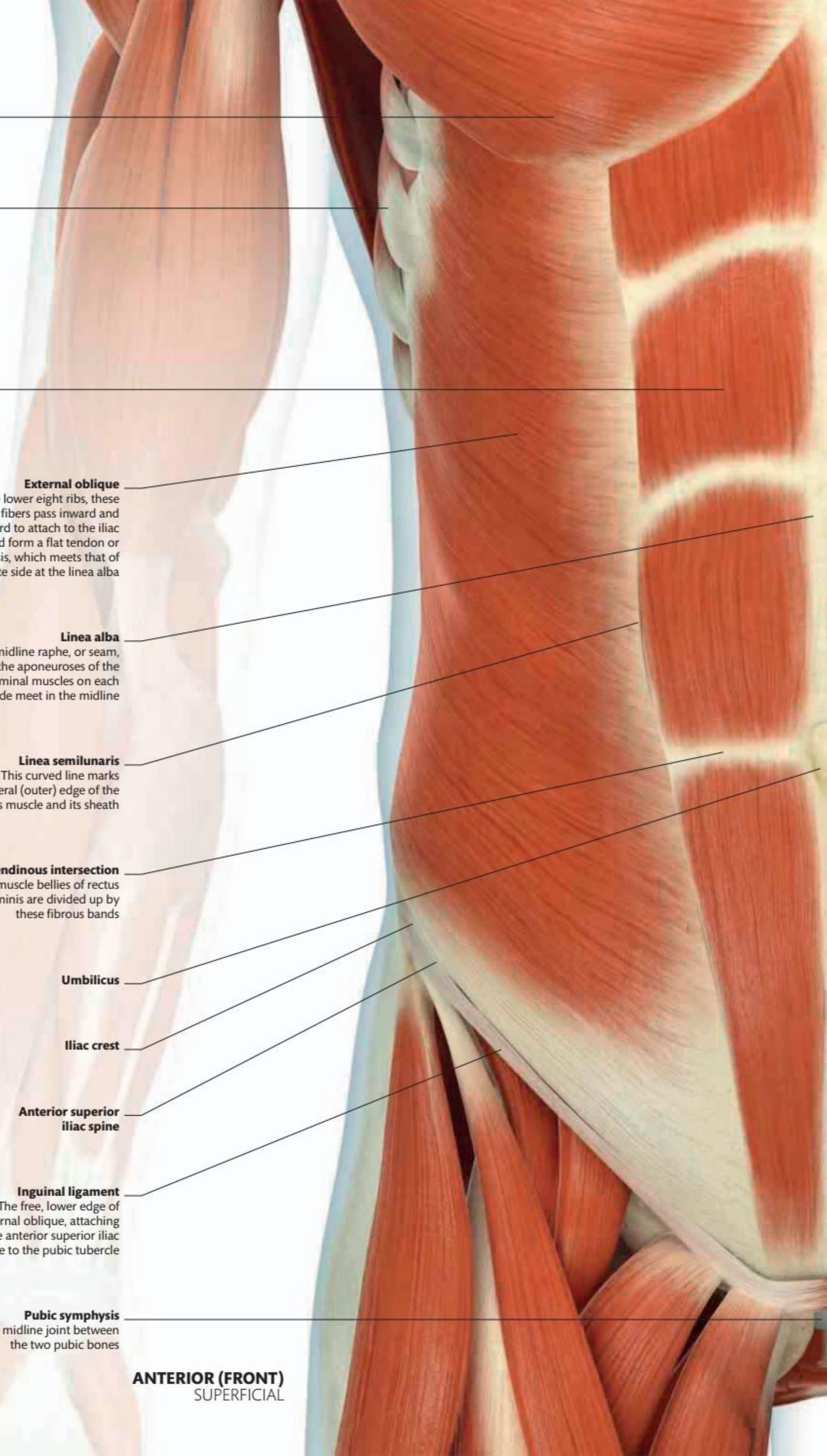

Pectoralis major

Serratus anterior

Rectus abdominis
Attaches from the lower costal cartilages, down to the pubic bones

External oblique
From the lower eight ribs, these muscle fibers pass inward and downward to attach to the iliac crest, and form a flat tendon or aponeurosis, which meets that of the opposite side at the linea alba

Linea alba
The midline raphe, or seam, where the aponeuroses of the abdominal muscles on each side meet in the midline

Linea semilunaris
This curved line marks the lateral (outer) edge of the rectus muscle and its sheath

Tendinous intersection
The muscle bellies of rectus abdominis are divided up by these fibrous bands

Umbilicus

Iliac crest

Anterior superior iliac spine

Inguinal ligament
The free, lower edge of the external oblique, attaching from the anterior superior iliac spine to the pubic tubercle

Pubic symphysis
The midline joint between the two pubic bones

ANTERIOR (FRONT)
SUPERFICIAL

ABDOMEN AND PELVIS

The abdominal muscles can move the trunk—flexing the spine to the front or to the side, or twisting the abdomen from side to side. They are very important muscles in posture, helping support the upright spine when we are standing or sitting, and are also called into action when we lift heavy objects. Because they compress the abdomen and raise the pressure internally, they are involved during defecation, micturition (emptying the bladder), and in forced expiration of air from the lungs. Right at the front, lying either side of the midline, there are two straight, straplike rectus abdominis muscles. These muscles are each broken up by horizontal tendons: in a well-toned, slim person, this creates the much-sought-after "six-pack" appearance. Flanking the recti muscles on each side are three layers of broad, flat muscles.

Posterior layer of rectus sheath
The rectus sheath is formed by the aponeuroses of the muscles to the sides: the external oblique, the internal oblique, and the transversus abdominis

Aponeurosis of internal oblique (cut edge)

Internal oblique
Lying underneath the external oblique, these muscle fibers spring from the inguinal ligament and iliac crest and fan inward and upward, attaching to the lower ribs and to each other in the midline

Arcuate line
At this point, all the aponeuroses of the lateral muscles swap to lie in front of the rectus abdominis muscles, leaving only a layer of fascia behind that muscle

Pubic tubercle

ANTERIOR (FRONT)
DEEP

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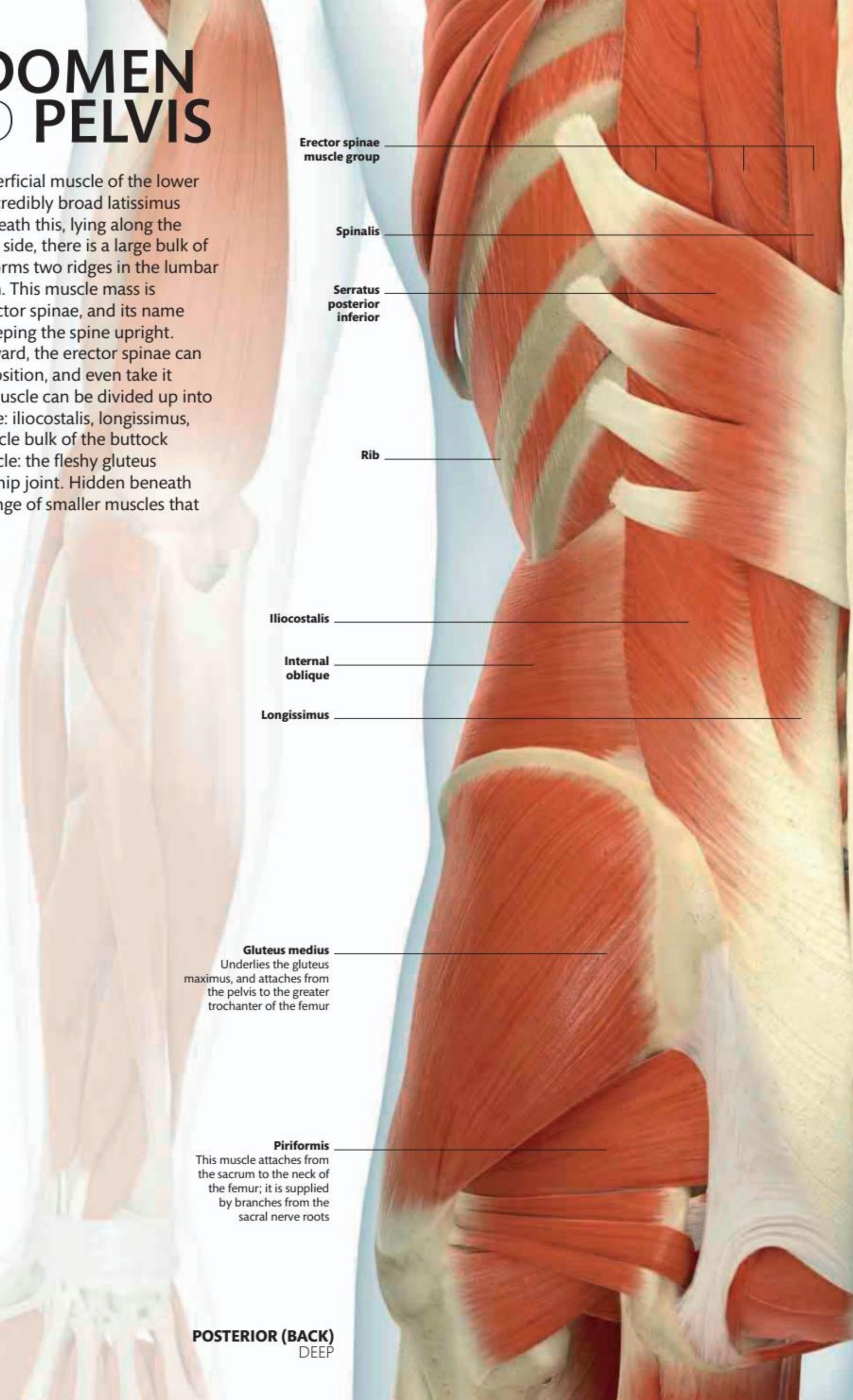
ABDOMEN AND PELVIS

The most superficial muscle of the lower back is the incredibly broad latissimus dorsi. Underneath this, lying along the spine on each side, there is a large bulk of muscle that forms two ridges in the lumbar region in a well-toned person. This muscle mass is collectively known as the erector spinae, and its name suggests its importance in keeping the spine upright. When the spine is flexed forward, the erector spinae can pull it back into an upright position, and even take it further, into extension. The muscle can be divided up into three main strips on each side: iliocostalis, longissimus, and spinalis. Most of the muscle bulk of the buttock comes down to just one muscle: the fleshy gluteus maximus, which extends the hip joint. Hidden beneath the gluteus maximus are a range of smaller muscles that also move the hip.



POSTERIOR (BACK)
DEEP

Trapezius

Latissimus dorsi
This massive muscle takes its attachment from a wide area: from the lower thoracic vertebrae, and from the lumbar vertebrae, sacrum, and iliac crest via the thoracolumbar fascia; its fibers converge on a narrow tendon, which attaches to the humerus

Thoracolumbar fascia

External oblique

Lumbar triangle

Iliac crest

Gluteus maximus
The largest and most superficial of the buttock muscles

POSTERIOR (BACK)
SUPERFICIAL

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SHOULDER AND UPPER ARM

The triangular deltoid muscle lies over the shoulder. Acting as a whole, this muscle raises the arm to the side (abduction), but the fibers of the deltoid attaching to the front of the clavicle can also move the arm forward. The pectoralis major muscle can also act on the shoulder joint, flexing the arm forward or pulling it in to the side of the chest (adduction). The biceps brachii muscle forms much of the muscle bulk on the front of the arm. The biceps tendon inserts on the radius, and also has an aponeurosis (flat tendon) that fans out over the forearm muscles. The biceps is a powerful flexor of the elbow, and can also rotate the radius to position the lower arm so the palm faces upward (supination).

Trapezius

Clavicle

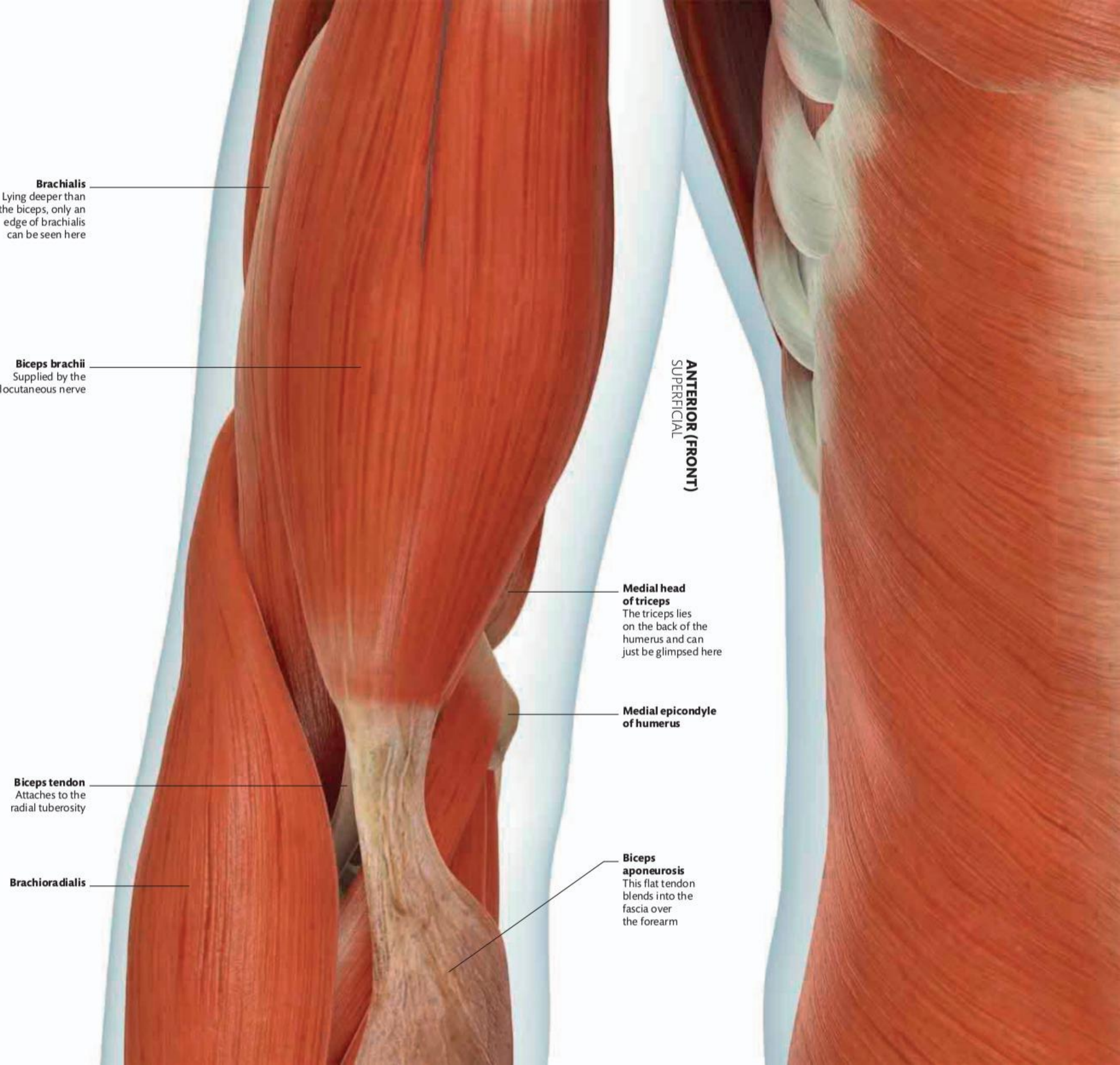
Acromion of scapula

Pectoralis major
Attaches from the chest to the upper shaft of the humerus; it is supplied by the pectoral nerves

Deltoid
This powerful muscle attaches from the clavicle, acromion, and spine of the scapula to the deltoid tuberosity on the side of the humerus

Long head of biceps
This tendon disappears under the deltoid sooner than the short head, so it appears to be the shorter of the two, but it runs right over the head of the humerus to attach to the scapula above the glenoid fossa

Short head of biceps
Attaches to the coracoid process of the scapula



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SHOULDER AND UPPER ARM

The posterior fibers of the deltoid attach from the spine of the scapula (shoulder blade) down to the humerus, and this part of the muscle can draw back the arm, or extend it. Latissimus dorsi (a broad muscle attaching from the back of the trunk and ending in a narrow tendon that secures onto the humerus) can also extend the arm. The triceps brachii muscle is the sole extensor of the elbow. In a superficial dissection (represented in this view) only two of the three heads of the triceps can be seen—the long and lateral heads. The triceps tendon attaches to the leverlike olecranon of the ulna, which forms the bony knobble at the back of the elbow.

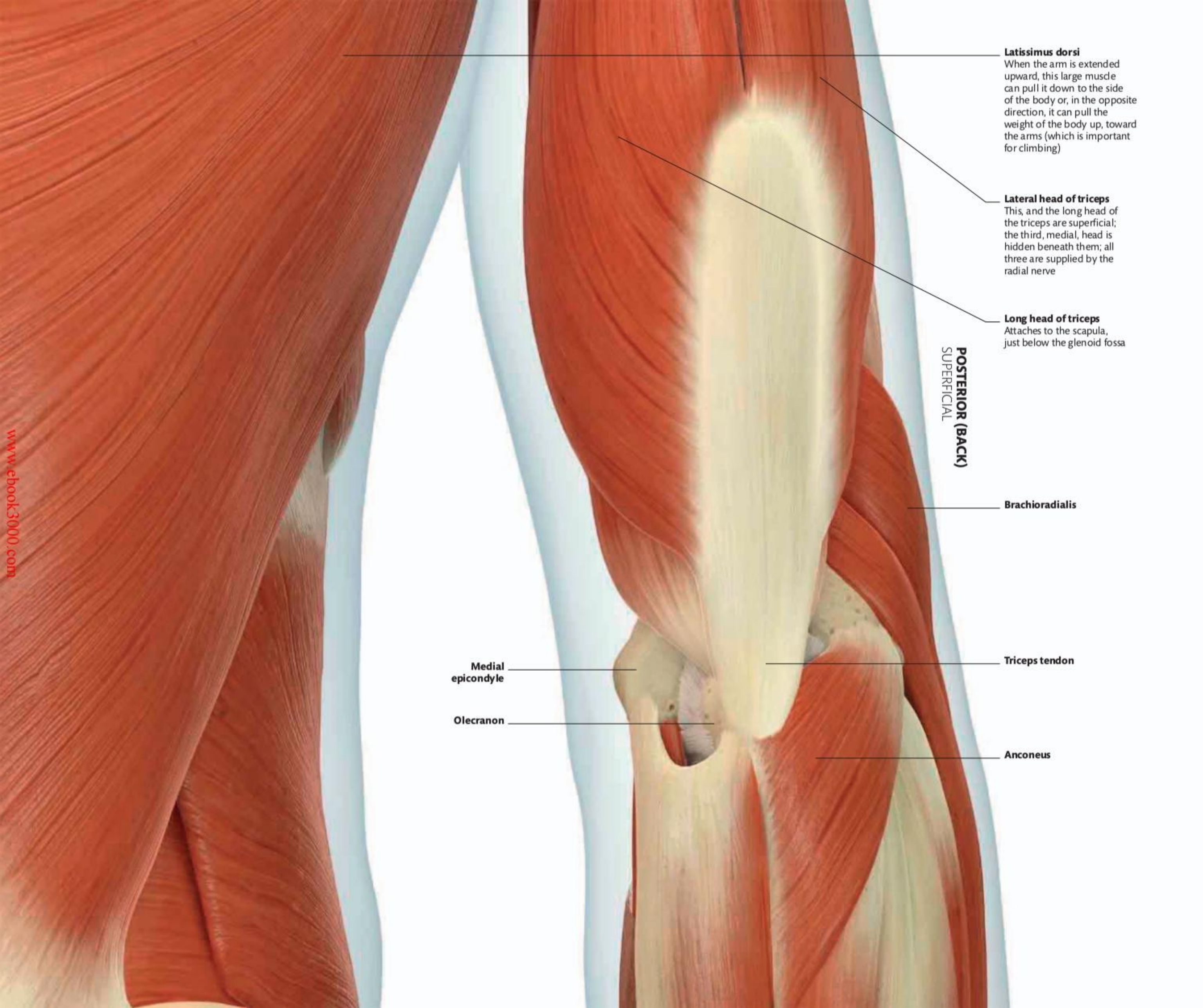
Deltoid

Infraspinatus
Attaches from the infraspinous fossa, below the spine of the scapula, to the back of the neck of the humerus; it can rotate the humerus along its axis, out to the side

Teres major
Attaches from the scapula to the front of the neck of the humerus, and rotates the humerus inward

Trapezius

Spine of scapula



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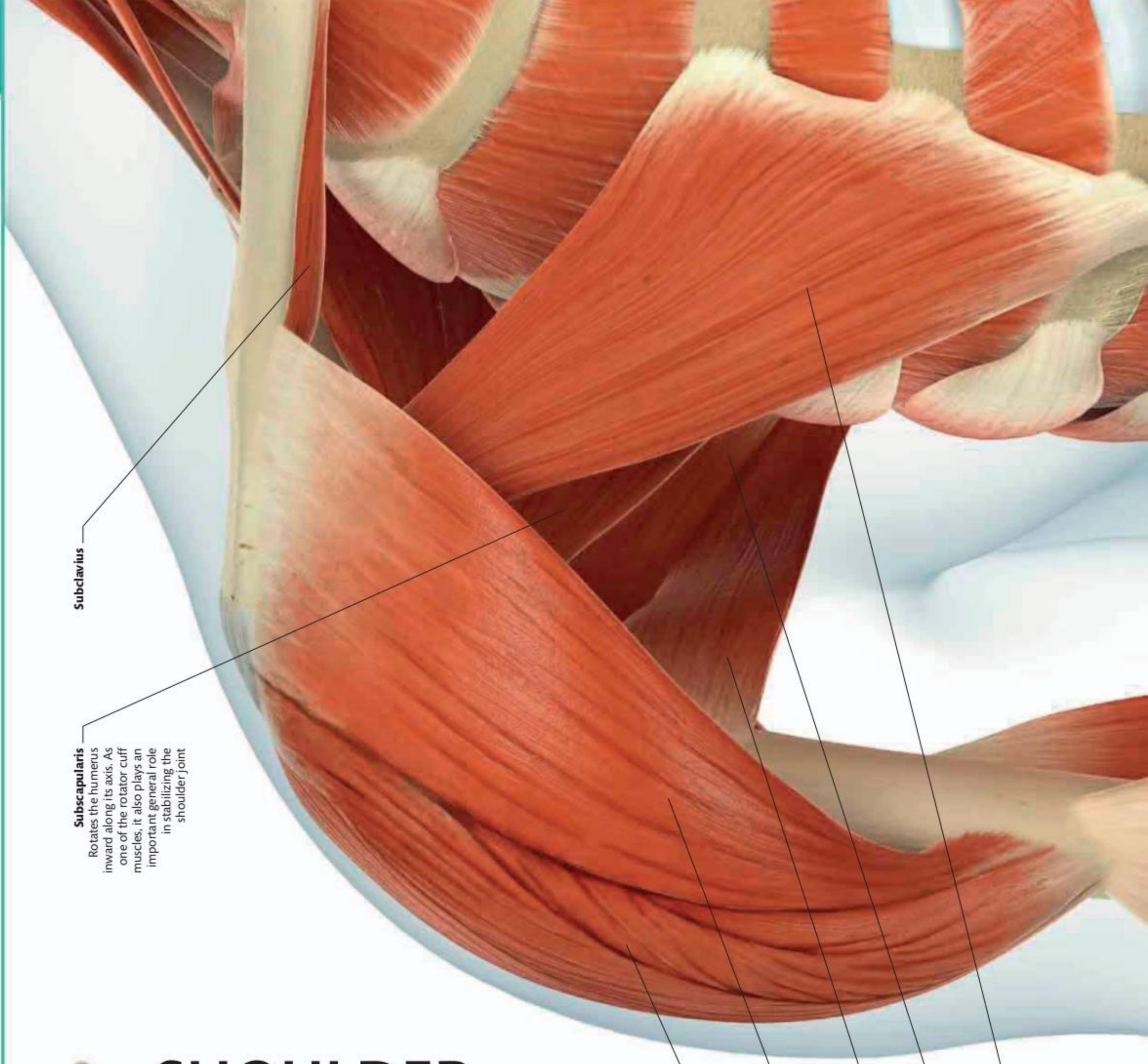
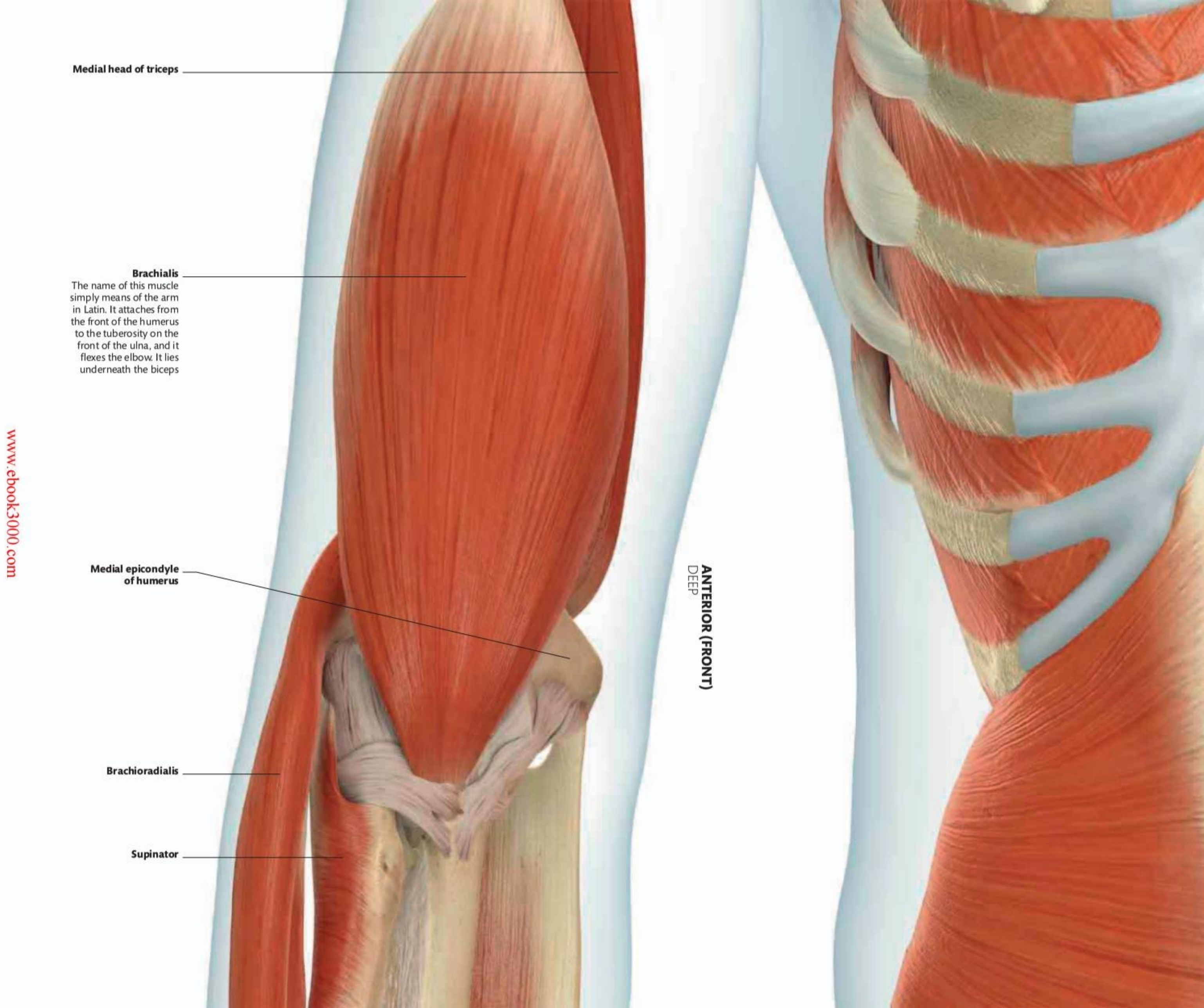


SHOULDER AND UPPER ARM

The deep muscles around the shoulder include the so-called rotator cuff group, two of which can be seen here: the subscapularis (which attaches from the deep surface of the scapula) and the supraspinatus (which runs from the scapula, over the shoulder joint, to attach to the humerus). The supraspinatus tendon passes through a narrow gap between the head of the humerus and the acromion of the scapula, and may become compressed and damaged here, in impingement syndrome. On the front of the humerus, the biceps (see p.85) has been removed to reveal brachialis, which runs from the lower humerus down to the ulna. Like the biceps, brachialis is a flexor of the elbow.



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SHOULDER AND UPPER ARM

More of the rotator cuff muscles—the supraspinatus, infraspinatus, and teres minor—can be seen from the back. In addition to moving the shoulder joint in various directions, including rotation, these muscles are important in helping to stabilize the shoulder joint: they hug the head of the humerus into its socket during movements at the shoulder. On the back of the arm, a deeper view reveals the third, medial head of the triceps, which attaches from the back of the humerus. It joins with the lateral and long heads to form the triceps tendon, attaching to the olecranon. Most of the forearm muscles take their attachment from the epicondyles of the humerus, just above the elbow, but the brachioradialis and extensor carpi radialis longus have higher origins from the side of the humerus, as shown here.

Posterior fibers of deltoid

Teres minor
Like infraspinatus, this muscle can laterally rotate the humerus along its axis

Teres major

Infraspinatus

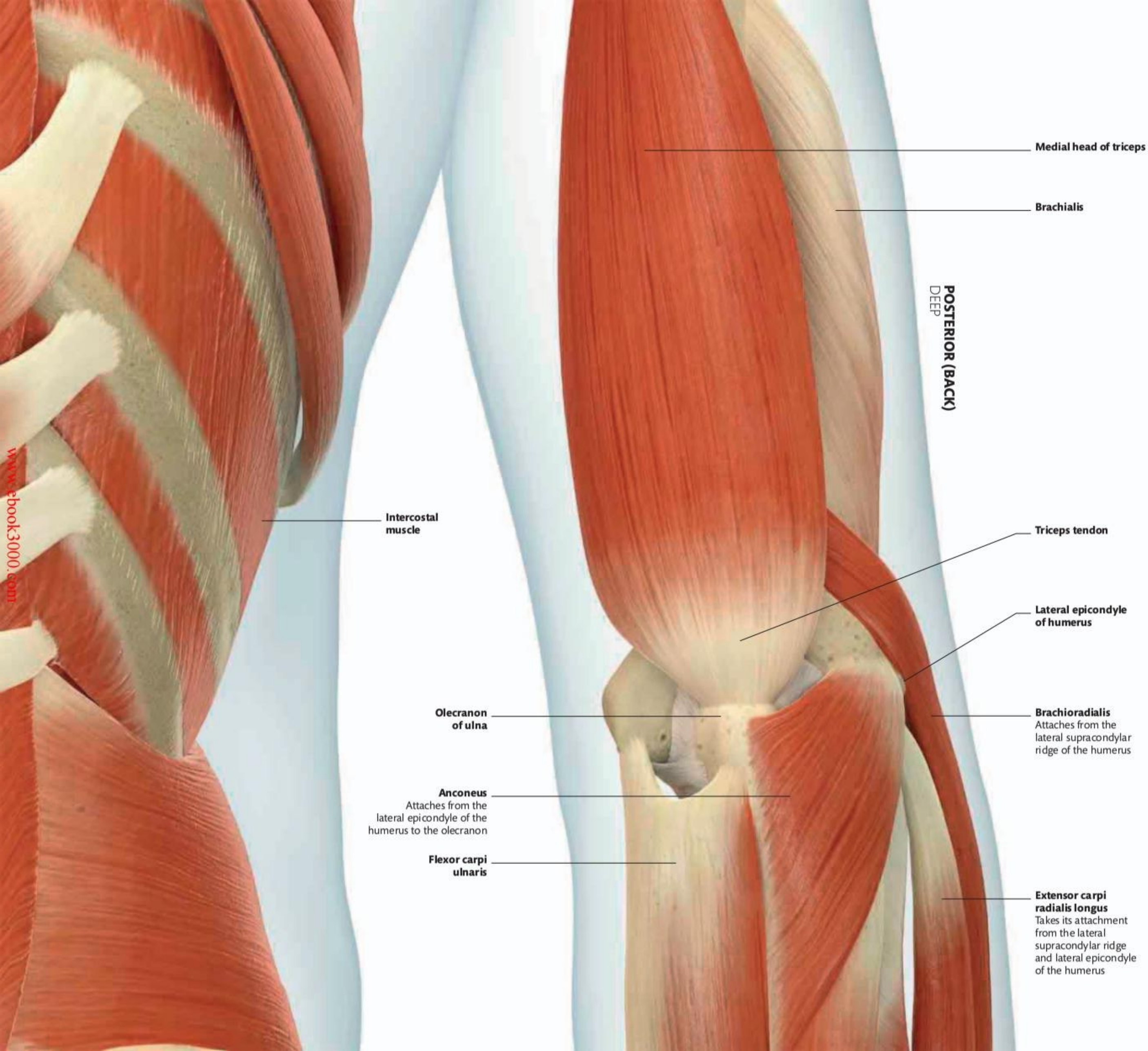
Shaft of humerus

Supraspinatus
Part of the rotator cuff muscle group, along with infraspinatus and teres minor—each of these muscles attaches to the greater tuberosity of the humerus

Spine of scapula

Medial border of scapula

Acromion of scapula



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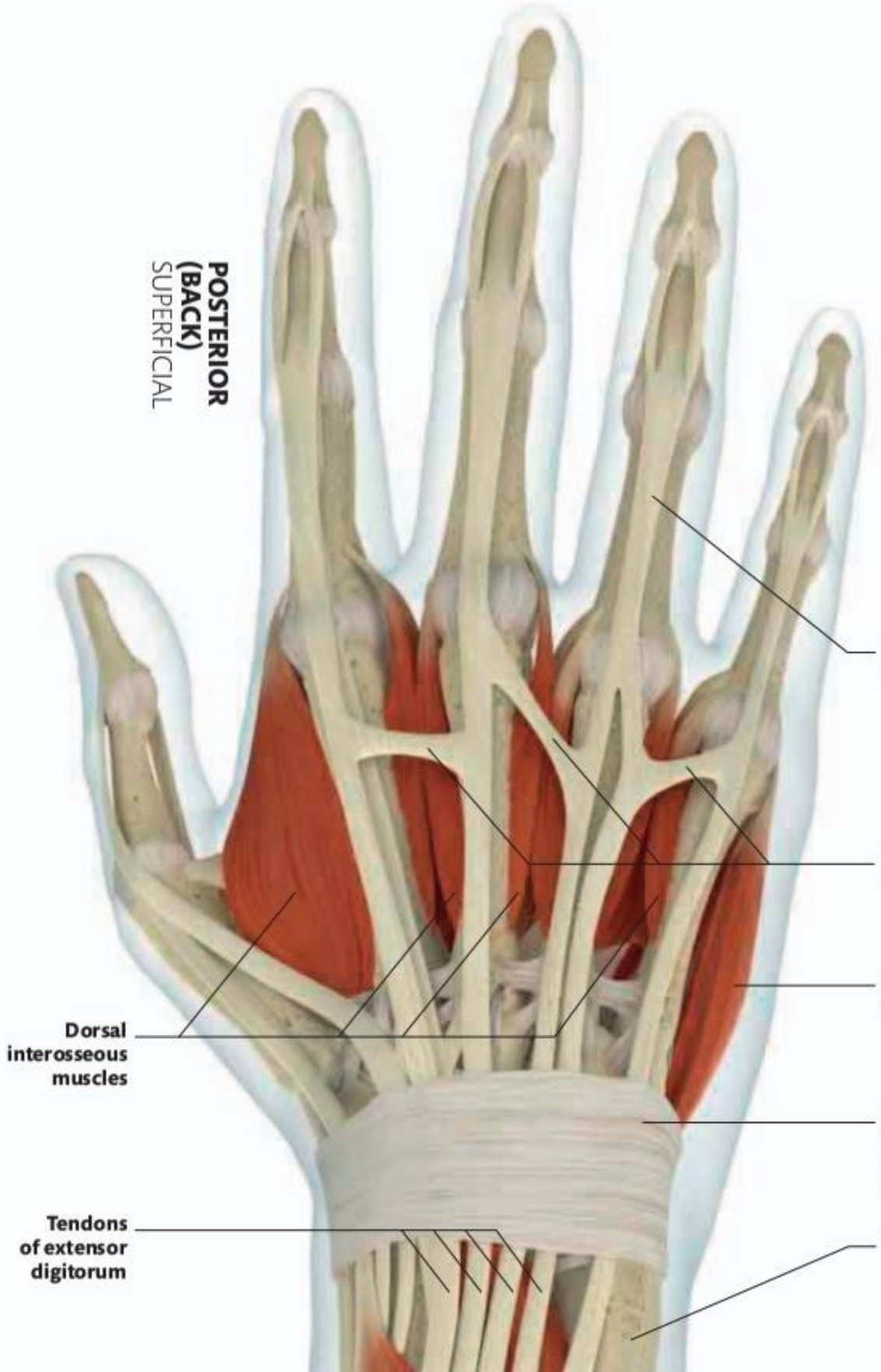
POSTERIOR (BACK) SUPERFICIAL



Extensor expansion

Intertendinous connections

Abductor digiti minimi

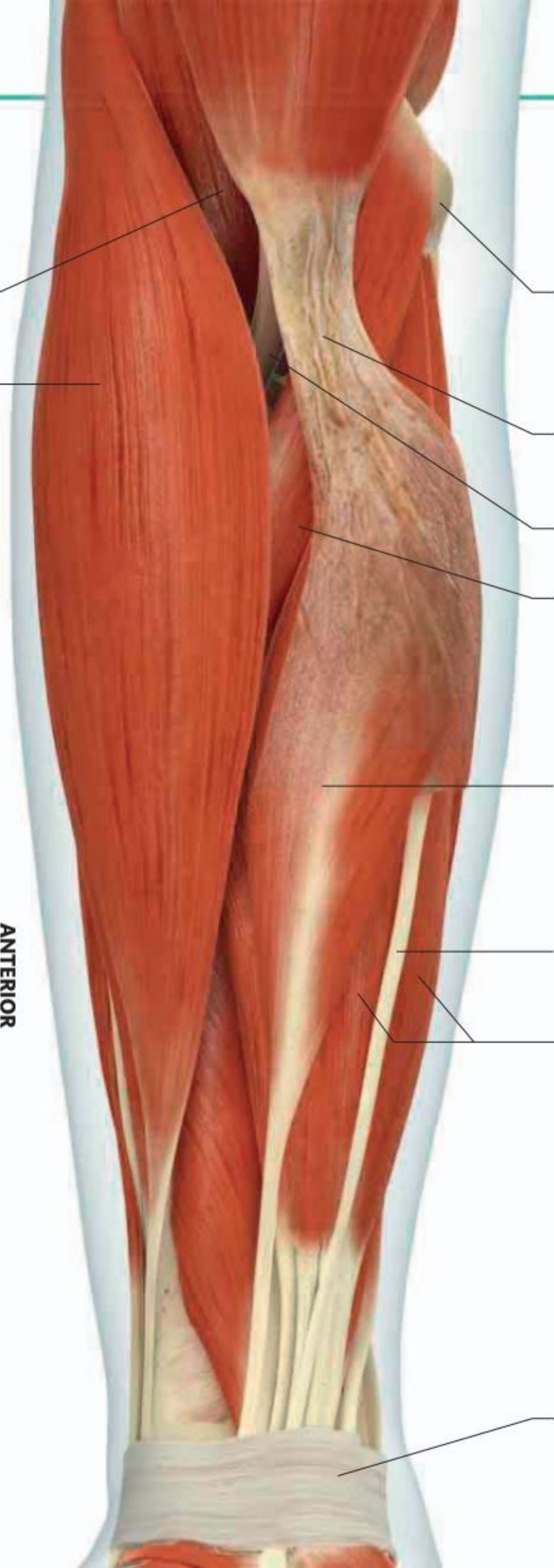
Dorsal interosseous muscles

Extensor retinaculum
This fibrous band keeps the extensor tendons close to the wrist

Tendons of extensor digitorum

Ulna

ANTERIOR (FRONT) SUPERFICIAL



Brachialis

Brachioradialis
Runs along the outer edge of the forearm and attaches to the end of the radius; it flexes and stabilizes the elbow

Medial epicondyle of humerus
Also called the common flexor origin; many of the superficial flexor muscles attach from this point

Biceps aponeurosis

Biceps tendon

Pronator teres
Attaches from the humerus and ulna down to the outer edge of the radius; it pronates the forearm, rotating the lower end of the radius around the ulna

Flexor carpi radialis
Radial extensor of the wrist; it arises from the medial epicondyle of the femur and secures on the base of the second metacarpal; it flexes the wrist and abducts the hand

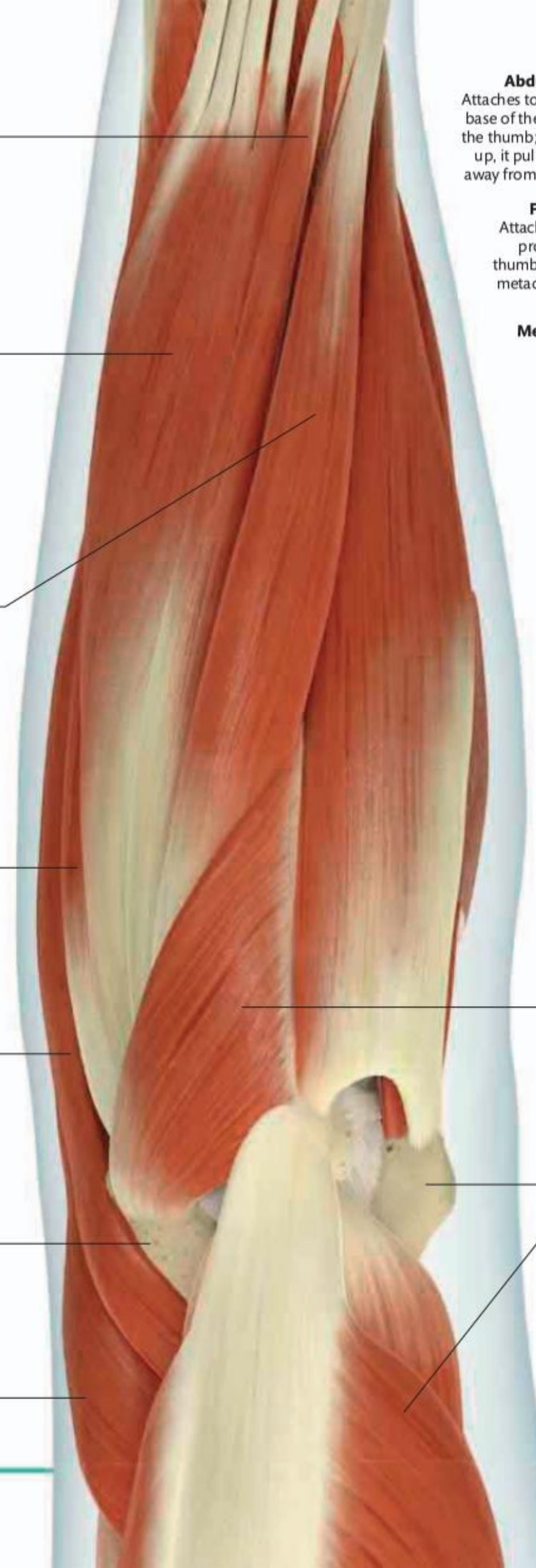
Palmaris longus tendon

Flexor digitorum superficialis
Takes its attachment from the humerus, ulna, and radius, and splits into four tendons that run across the wrist into the hand, to flex the fingers

Flexor retinaculum
This fibrous band keeps the flexor tendons close to the wrist and stops them bow-stringing outward

LOWER ARM AND HAND

There are five superficial muscles on the front of the forearm, all taking their attachment from the medial epicondyle of the humerus. Pronator teres attaches across to the radius, and can pull this bone into pronation (held with the palm turned downward). The other muscles run farther down the forearm, becoming slender tendons that attach around the wrist, or continue into the hand. Flexor digitorum superficialis splits into four tendons, one for each finger. On the back of the forearm, seven superficial extensor muscles attach to the lateral epicondyle of the humerus. Most of these tendons run down to the wrist or into the hand.



Extensor digiti minimi
The tendon of this extensor of the little finger joins the tendon of the extensor digitorum on the back of the little finger

Extensor digitorum
Extensor of the fingers; it takes its attachment from the lateral epicondyle and becomes four tendons that fan out over the back of the fingers, forming the "extensor expansion"

Extensor carpi ulnaris
Ulnar extensor of the wrist; it arises from the lateral epicondyle and attaches to the base of the fifth metacarpal; it extends the wrist and adducts the hand

Extensor carpi radialis brevis
Short extensor of the wrist; attaches from the lateral epicondyle to the third metacarpal in the hand

Extensor carpi radialis longus
Long extensor of the wrist; it attaches from the lateral supracondylar ridge all the way down to the base of the second metacarpal

Lateral epicondyle of humerus
Referred to as the common extensor origin—many forearm extensor muscles attach here

Brachioradialis

Anconeus
Acts with the triceps to extend the elbow joint

Olecranon

Triceps

Abductor pollicis brevis
Attaches to the outer side of the base of the proximal phalanx of the thumb; with the palm facing up, it pulls the thumb upward, away from the palm and fingers

Flexor pollicis brevis
Attaches to the base of the proximal phalanx of the thumb; it flexes the thumb's metacarpophalangeal joint

Metacarpophalangeal joint

First proximal phalanx

Tendons of flexor digitorum superficialis
These four tendons each split to insert either side of the middle phalanx of a finger; they flex the proximal interphalangeal joints

Tendons of flexor digitorum profundus
These tendons emerge through the superficial tendon and continue on, to attach to a distal phalanx; they flex the distal interphalangeal joints of the fingers

Abductor digiti minimi

Flexor digiti minimi brevis
Short flexor of the little finger; it flexes the little finger's metacarpophalangeal joint

Palmar aponeurosis

Lumbricals
These small muscles are named after the Latin for worm

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POSTERIOR (BACK)
DEEP

Dorsal interosseous muscles
These muscles spread the fingers

Extensor retinaculum

Extensor pollicis brevis
Extensor of the index finger; it joins the tendon of extensor digitorum (see pp.92–93) of the index finger

Extensor pollicis brevis
Short extensor of the thumb; it attaches to the proximal phalanx and pulls the thumb out to the side

Supinator

Brachialis

Medial epicondyle of humerus
Also known as the common flexor origin

ANTERIOR (FRONT)
DEEP

Brachioradialis

Flexor carpi ulnaris

Flexor pollicis longus
This long flexor of the thumb arises from the radius and interosseous membrane; its tendon runs into the thumb to attach to the base of the distal phalanx

Flexor retinaculum

LOWER ARM AND HAND

Stripping away the superficial muscles on the front of the forearm reveals a deeper layer attaching to the radius and ulna, and to the interosseous membrane between the bones. The long, quill-like flexor of the thumb (flexor pollicis longus) can be seen clearly. Deep muscles on the back of the forearm include the long extensors of the thumb and index finger and the supinator, which pulls on the radius to rotate the pronated arm (held with palm facing downward) into supination (with palm facing up). In the hand, a deep dissection reveals the interosseous muscles that act on the metacarpophalangeal joints in order to either spread or close the fingers.

Extensor pollicis longus
Long extensor of the thumb; it attaches onto the thumb's distal phalanx

Abductor pollicis longus
Long abductor of the thumb; it attaches to the base of the thumb's metacarpal

Extensor carpi ulnaris

Supinator
Arises from the lateral epicondyle of the humerus and wraps around the radius; it pulls the pronated forearm back into supination

Extensor carpi radialis brevis

Extensor carpi radialis longus

Anconeus

Triceps

Opponens pollicis
Opposer of the thumb; it attaches to the outer border of the thumb's metacarpal and pulls that metacarpal across the palm—in a movement known as opposition

Metacarpal of thumb

First proximal phalanx

Adductor pollicis
This muscle attaches to the first proximal phalanx and pulls the abducted (bent outward) thumb back in toward the palm

Opponens digiti minimi
Opposer of the little finger; it draws the metacarpal of the little finger in towards the palm

Metacarpal of little finger

Palmar interosseous muscles
Interosseous means between bones; these muscles lie in the gaps between the metacarpals. They adduct (bring together) the fingers

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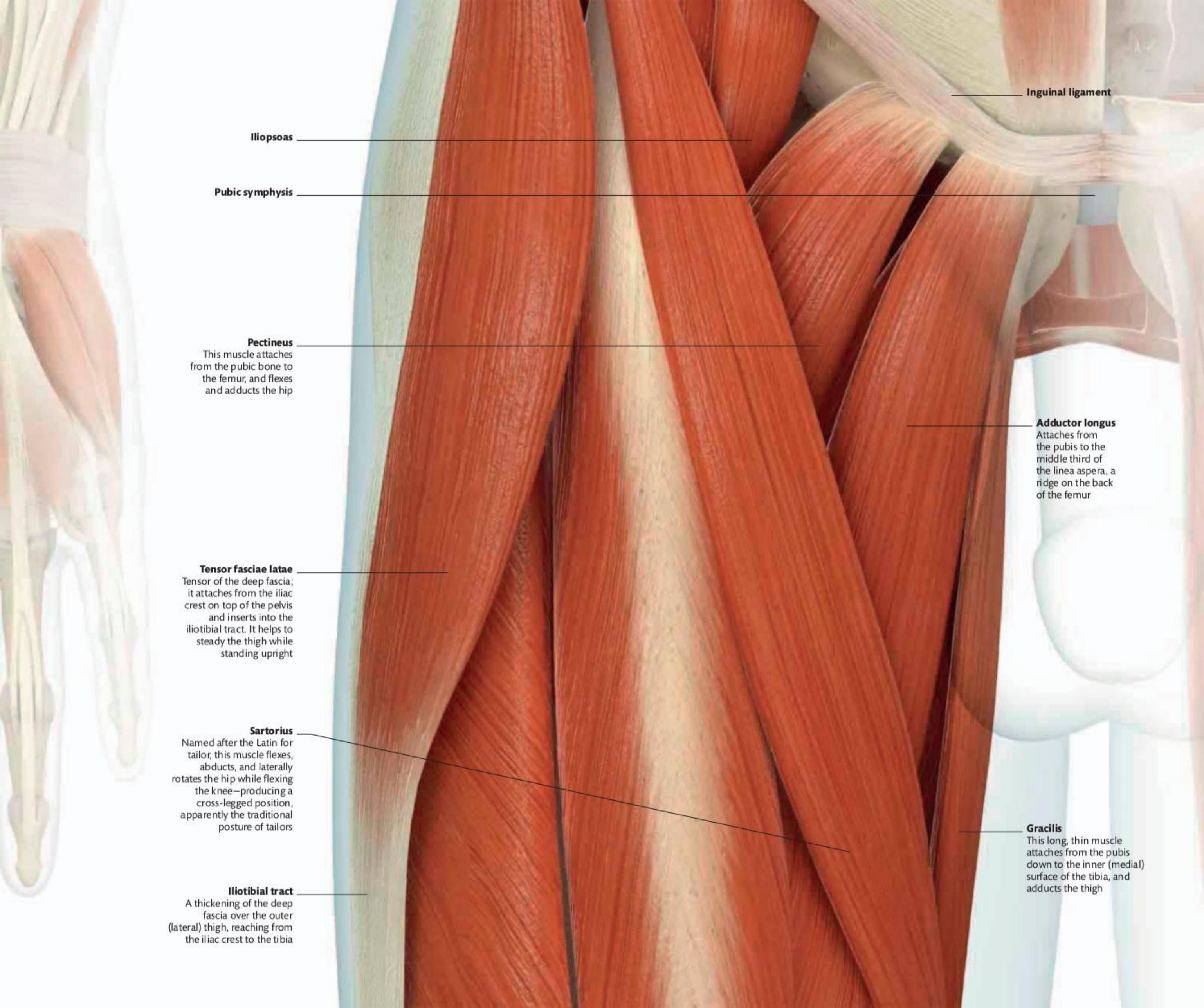
Inguinal ligament
Iliopsoas
Pubic symphysis
Pectineus
This muscle attaches from the pubic bone to the femur, and flexes and adducts the hip
Adductor longus
Attaches from the pubis to the middle third of the linea aspera, a ridge on the back of the femur
Tensor fasciae latae
Tensor of the deep fascia; it attaches from the iliac crest on top of the pelvis and inserts into the iliotibial tract. It helps to steady the thigh while standing upright
Sartorius
Named after the Latin for tailor, this muscle flexes, abducts, and laterally rotates the hip while flexing the knee—producing a cross-legged position, apparently the traditional posture of tailors
Gracilis
This long, thin muscle attaches from the pubis down to the inner (medial) surface of the tibia, and adducts the thigh
Iliotibial tract
A thickening of the deep fascia over the outer (lateral) thigh, reaching from the iliac crest to the tibia

Vastus medialis
Another large head of the quadriceps femoris

Quadriceps tendon
The four heads of quadriceps femoris come together in one tendon at the knee

Prepatellar bursa

Patellar ligament
The continuation of quadriceps tendon below the patella

Rectus femoris
The part of the quadriceps that can flex the hip as well as extend the knee

Vastus lateralis
The name of this part of the quadriceps reflects its impressive size

ANTERIOR (FRONT)
SUPERFICIAL

HIP AND THIGH

Most of the muscle bulk on the front of the leg is the four-headed quadriceps femoris. Three of its heads can be seen in a superficial dissection of the thigh: the rectus femoris, vastus lateralis, and vastus medialis. The quadriceps extends the knee, but it can also flex the hip, since the rectus femoris part has an attachment from the pelvis, above the hip joint. The patella is embedded in the quadriceps tendon; this may protect the tendon from wear and tear, but it also helps to give the quadriceps good leverage in extending the knee. The part of the tendon below the patella is usually called the patellar ligament. Tapping this with a tendon hammer produces a reflex contraction in the quadriceps—the "knee jerk".

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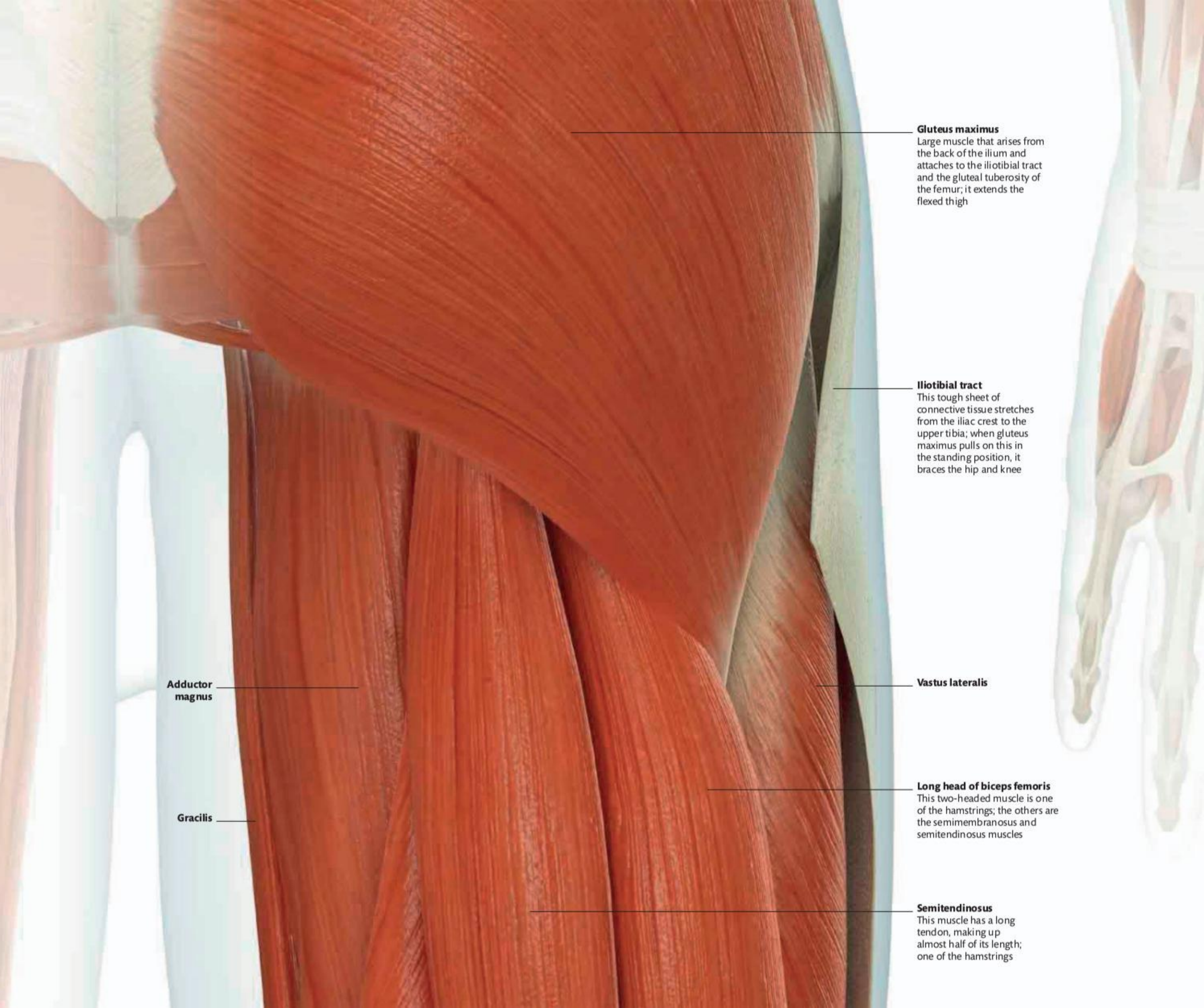


Gluteus maximus
Large muscle that arises from the back of the ilium and attaches to the iliotibial tract and the gluteal tuberosity of the femur; it extends the flexed thigh

Iliotibial tract
This tough sheet of connective tissue stretches from the iliac crest to the upper tibia; when gluteus maximus pulls on this in the standing position, it braces the hip and knee

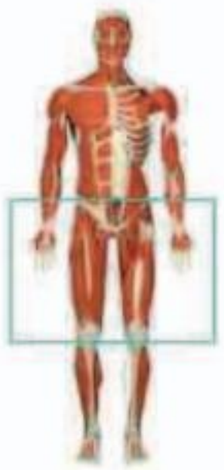
Adductor magnus

Vastus lateralis

Gracilis

Long head of biceps femoris
This two-headed muscle is one of the hamstrings; the others are the semimembranosus and semitendinosus muscles

Semitendinosus
This muscle has a long tendon, making up almost half of its length; one of the hamstrings



HIP AND THIGH

On the back of the hip and thigh, a superficial dissection reveals the large gluteus maximus, an extensor of the hip joint, and the three hamstrings. The gluteus maximus acts to extend the hip joint, swinging the leg backward. While it doesn't really contribute to gentle walking, it is very important in running, and also when the hip is being extended from a flexed position, such as when getting up from sitting on the floor or when climbing the stairs. The hamstrings—the semimembranosus, semitendinosus, and biceps femoris muscles—attach from the ischial tuberosity of the pelvis and sweep down the back of the thigh to the tibia and fibula. They are the main flexors of the knee.

POSTERIOR (BACK)
SUPERFICIAL

Semimembranosus
The third of the hamstrings

Medial head of gastrocnemius

Lateral head of gastrocnemius

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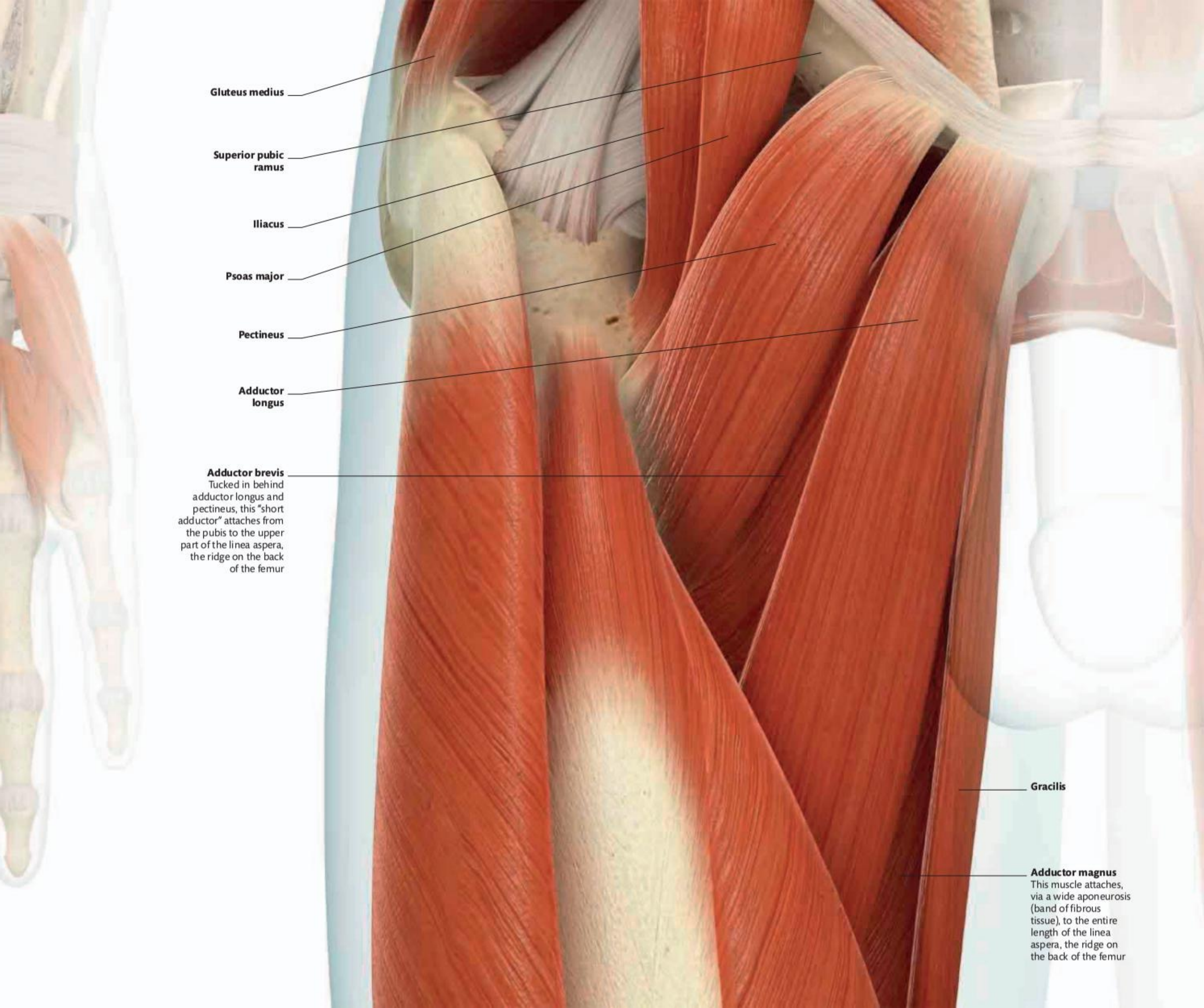
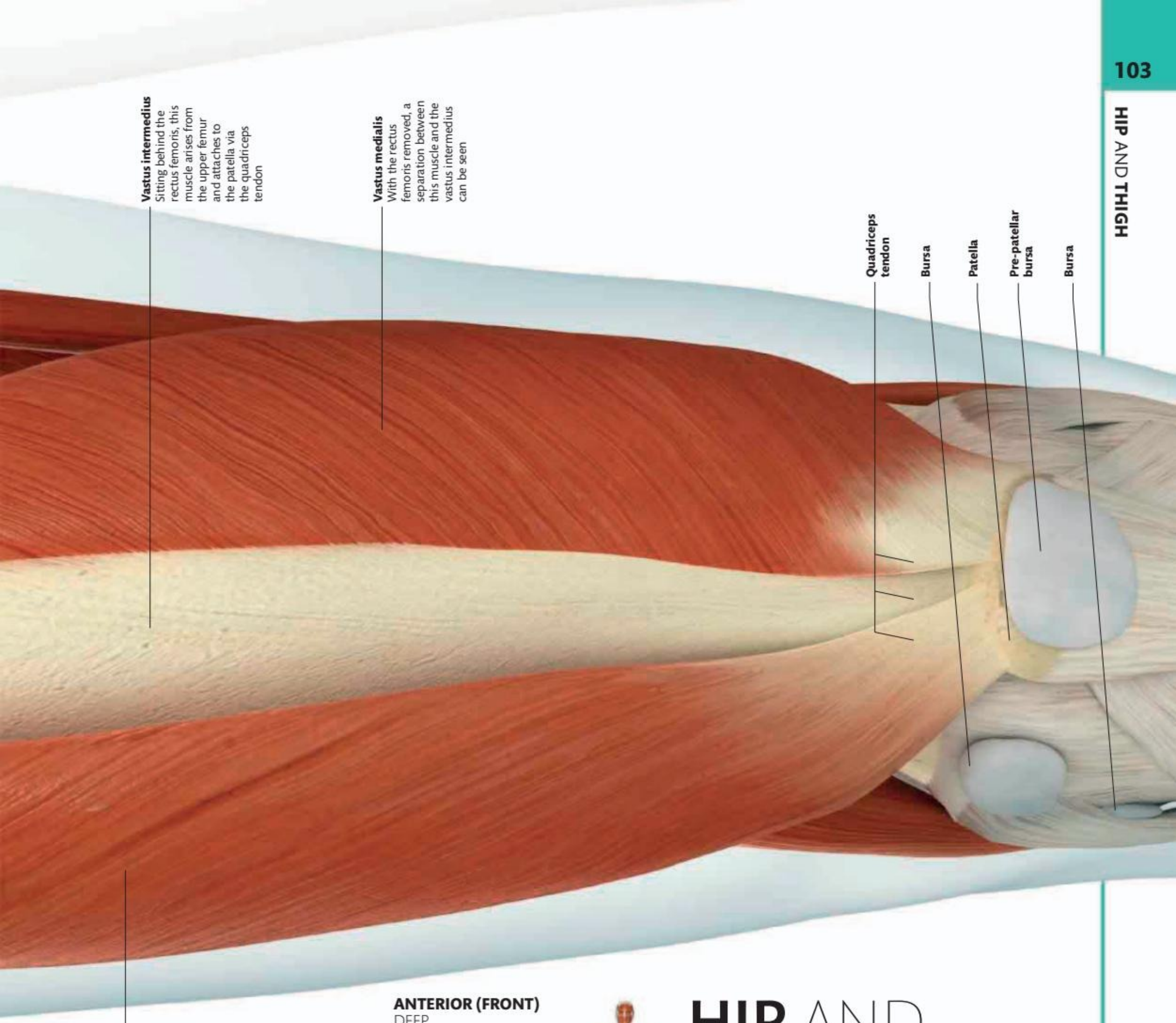

Gluteus medius
Superior pubic ramus
Iliacus
Psoas major
Pectineus
Adductor longus
Adductor brevis
Tucked in behind adductor longus and pectineus, this "short adductor" attaches from the pubis to the upper part of the linea aspera, the ridge on the back of the femur
Gracilis
Adductor magnus
This muscle attaches, via a wide aponeurosis (band of fibrous tissue), to the entire length of the linea aspera, the ridge on the back of the femur



HIP AND THIGH

With the rectus femoris and sartorius muscles stripped away, we can see the deep, fourth head of the quadriceps, known as vastus intermedius. The adductor muscles that bring the thighs together can also be seen clearly, including the gracilis, which is long and slender, as its name suggests. The largest adductor muscle—the adductor magnus—has a hole in its tendon, through which the main artery of the leg (the femoral artery) passes. The adductor tendons attach from the pubis and ischium of the pelvis, and the sporting injuries referred to as "groin pulls" are often tears in these particular tendons.

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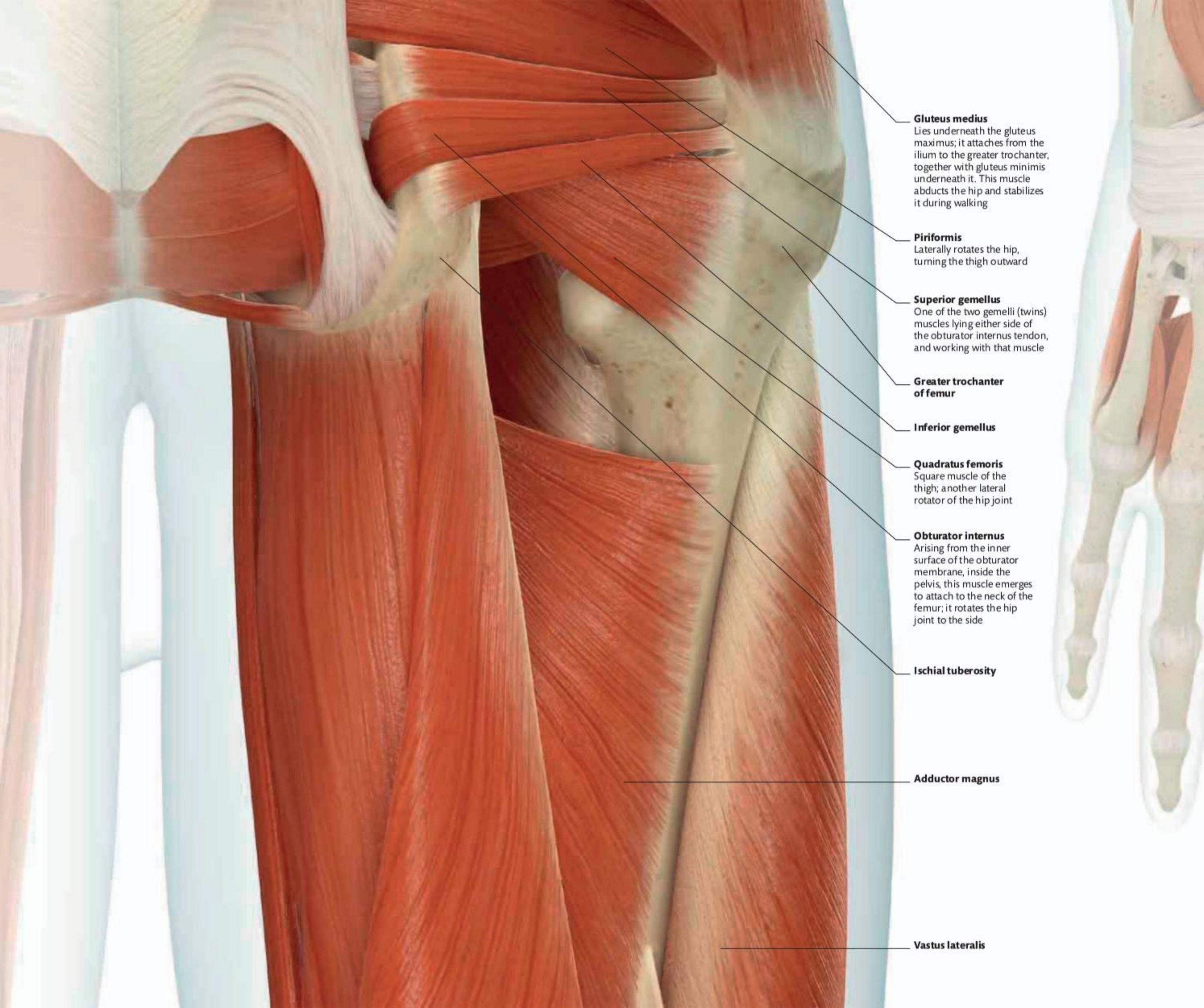


Gluteus medius
Lies underneath the gluteus maximus; it attaches from the ilium to the greater trochanter, together with gluteus minimis underneath it. This muscle abducts the hip and stabilizes it during walking

Piriformis
Laterally rotates the hip, turning the thigh outward

Superior gemellus
One of the two gemelli (twins) muscles lying either side of the obturator internus tendon, and working with that muscle

Greater trochanter of femur

Inferior gemellus

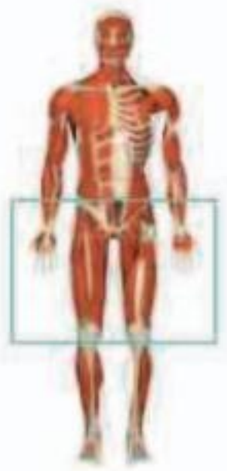
Quadratus femoris
Square muscle of the thigh; another lateral rotator of the hip joint

Obturator internus
Arising from the inner surface of the obturator membrane, inside the pelvis, this muscle emerges to attach to the neck of the femur; it rotates the hip joint to the side

Ischial tuberosity

Adductor magnus

Vastus lateralis



HIP AND THIGH

On the back of the hip, with the gluteus maximus removed, the short muscles that rotate the hip out to the side are clearly revealed. These include the piriformis, obturator internus, and quadratus femoris muscles. With the long head of the biceps femoris removed, we can now see the deeper, short head attaching to the linea aspera on the back of the femur. The semitendinosus muscle has also been cut away to reveal the semimembranosus underneath it, with its flat, membranelike tendon at the top. Popliteus muscle is also visible at the back of the knee joint, as is one of the many fluid filled bursae around the knee.

POSTERIOR (BACK)
DEEP

Semimembranosus
The upper, flattened part of this muscle gives it its name; this is one of the hamstrings, and a flexor of the knee

Short head of biceps femoris
Biceps femoris, the "two-headed muscle of the thigh", is one of the hamstrings, which act to flex the knee

Popliteal surface of femur
Triangular area of the lower end of the femur

Bursa

Popliteus

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ANTERIOR (FRONT)
SUPERFICIAL

Patella

Prepatellar bursa

Patellar ligament

Fibularis (peroneus) longus

Medial head of gastrocnemius

Tibialis anterior
Attaches to the medial cuneiform bone and first metatarsal; dorsiflexes the ankle (raises the foot upward)

Sartorius

Semimembranosus

Semitendinosus

Biceps femoris

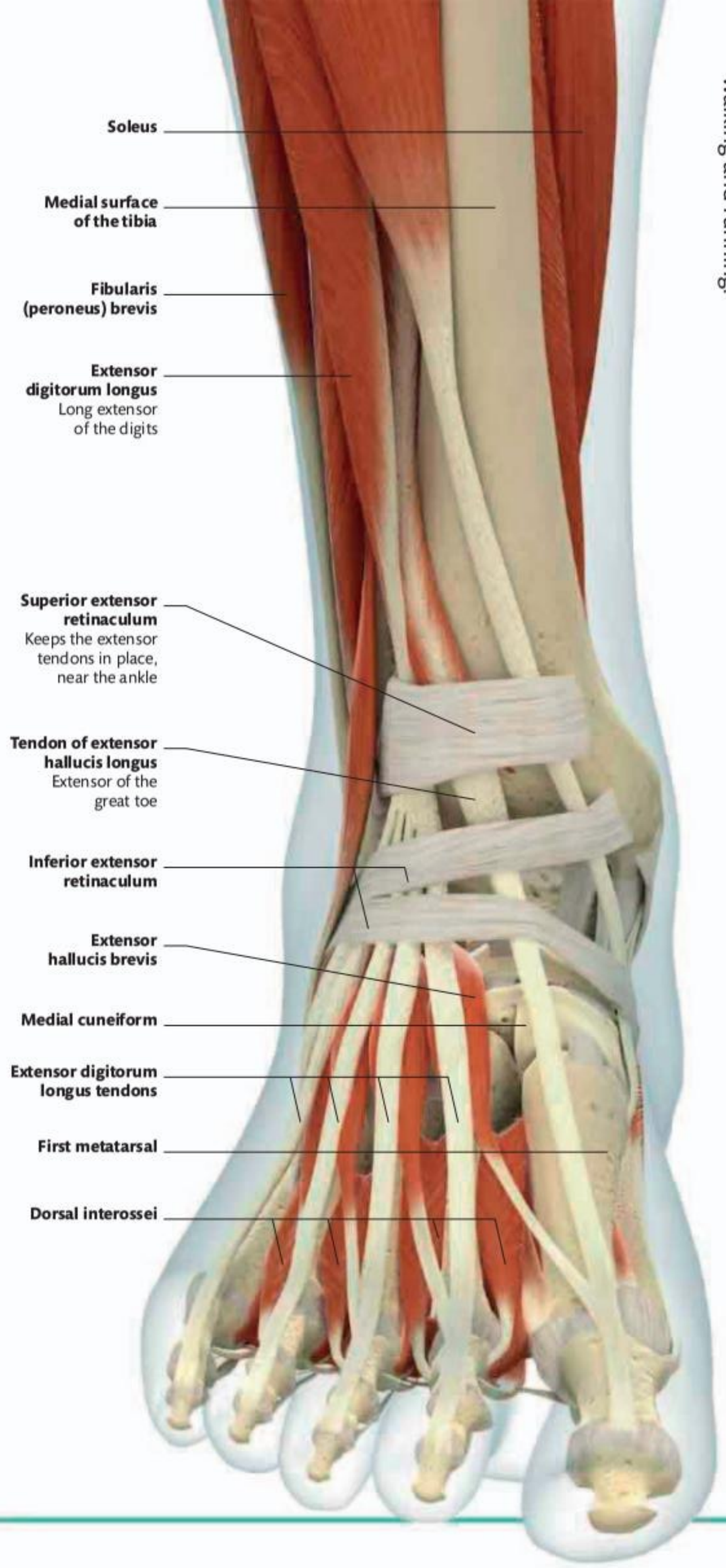
Medial head of gastrocnemius

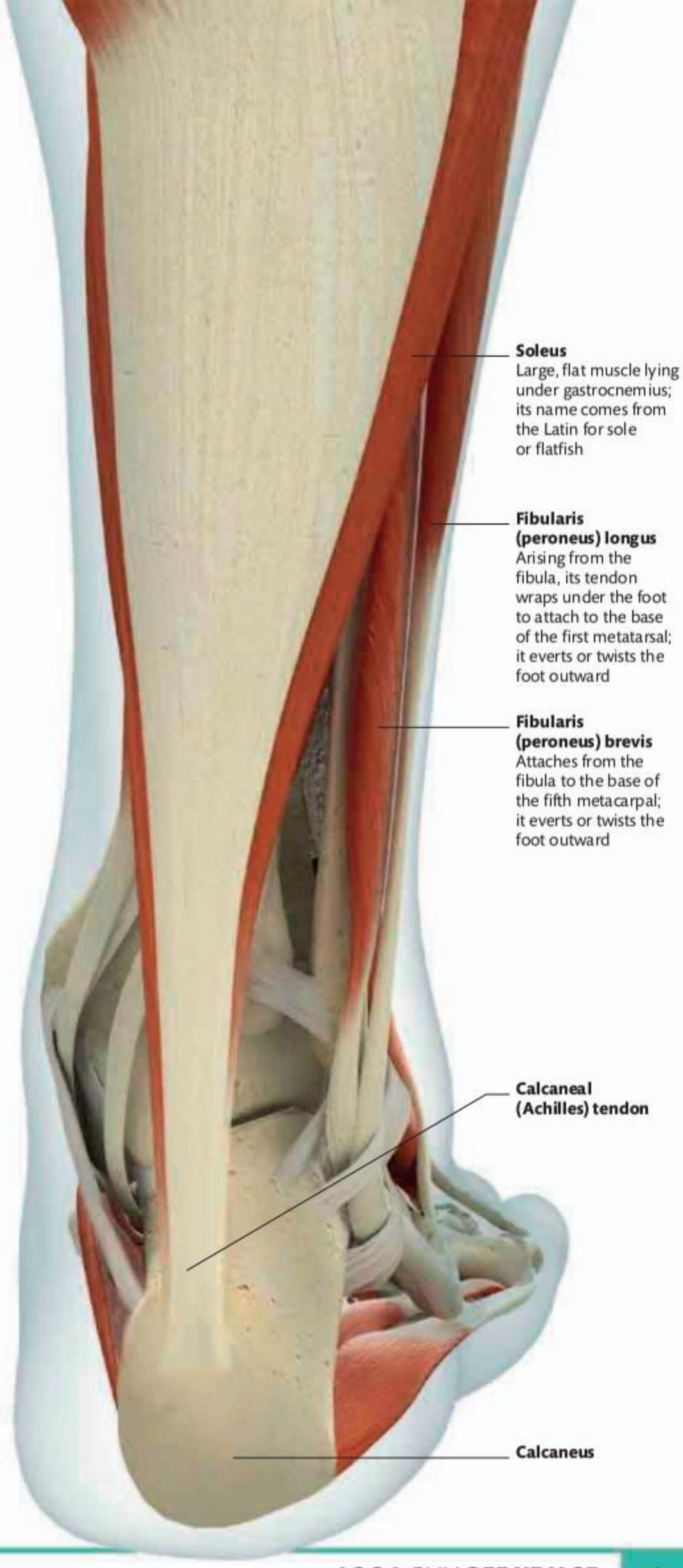
Lateral head of gastrocnemius

POSTERIOR (BACK)
SUPERFICIAL

LOWER LEG AND FOOT

You can feel the medial surface of the tibia easily, just under the skin on the front of your lower leg, on the inner side. Move your fingers outward, and you feel the sharp border of the bone, and then a soft wedge of muscles alongside it. These muscles have tendons that run down to the foot. They can pull the foot upward at the ankle, in a movement called dorsiflexion. Some extensor tendons continue all the way to the toes. There are much bulkier muscles on the back of the leg, and these form the calf. The gastrocnemius, and soleus underneath it, are large muscles that join together to form the Achilles tendon. They pull up on the lever of the calcaneus, pushing the ball of the foot down. They are involved as the foot pushes off from the ground during walking and running.





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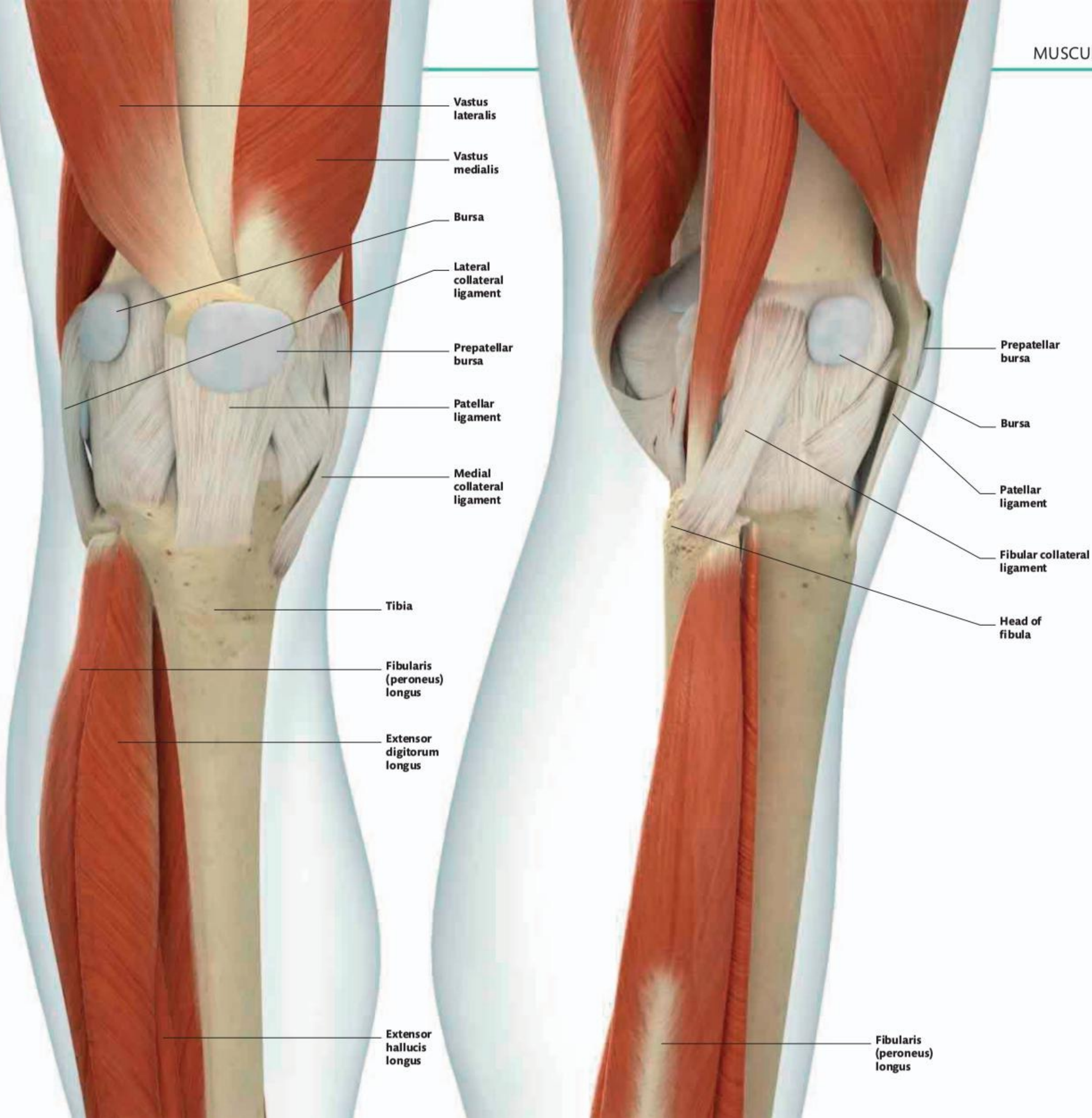
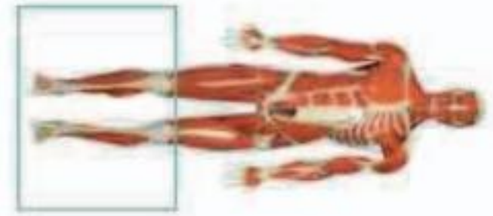

Vastus lateralis
Vastus medialis
Bursa
Lateral collateral ligament
Prepatellar bursa
Patellar ligament
Medial collateral ligament
Tibia
Fibularis (peroneus) longus
Extensor digitorum longus
Extensor hallucis longus
Prepatellar bursa
Bursa
Patellar ligament
Fibular collateral ligament
Head of fibula
Fibularis (peroneus) longus

LOWER LEG AND FOOT



Two muscles run along the outer, or lateral, side of the leg, down into the foot: the fibularis longus and fibularis brevis (see pp.104–05). These muscles pull the outer side of the foot upward, in a movement called eversion. The tendon of fibularis longus runs right underneath the foot, to attach on the inner side, and helps to maintain the transverse arch of the foot. The flexor hallucis longus arises from the fibula and interosseous membrane, and sends its tendon down, behind the medial malleolus and into the sole of the foot, to attach to the distal phalanx of the big toe.

ANTERIOR (FRONT)
DEEP

LATERAL (OUTSIDE)
DEEP

Superior extensor retinaculum
Holds the tendons close to the bone

Extensor digitorum longus tendon

Inferior extensor retinaculum

Extensor hallucis longus tendon
Pulls the big toe, or hallux, upward

Flexor hallucis longus

Medial malleolus

Tibialis posterior
This muscle inverts the foot, or twists it inward; its tendon passes into the foot, to attach to the navicular bone

Fibularis (peroneus) longus tendon

First metatarsal

First proximal phalanx

First distal phalanx

Extensor digitorum longus

Fibularis (peroneus) tertius

Extensor hallucis longus tendon
Attaches to the first distal phalanx; extends or pulls up the great, or big, toe

Extensor digitorum brevis
"Short extensor of the digits"; this muscle arises from the calcaneus (heel bone) and sends four tendons to the great, second, third, and fourth toes

Calcaneus

Abductor digiti minimi
"Abductor of the little toe"

Fibularis (peroneus) brevis tendon

Dorsal interosseous muscle
Like the dorsal interosseous muscles of the fingers, these muscles abduct, splaying the toes

Extensor digitorum longus tendons
Four tendons spread out across the back of the foot; each one forms an "extensor expansion" (like that in the fingers), attaching to the phalanges of the toes

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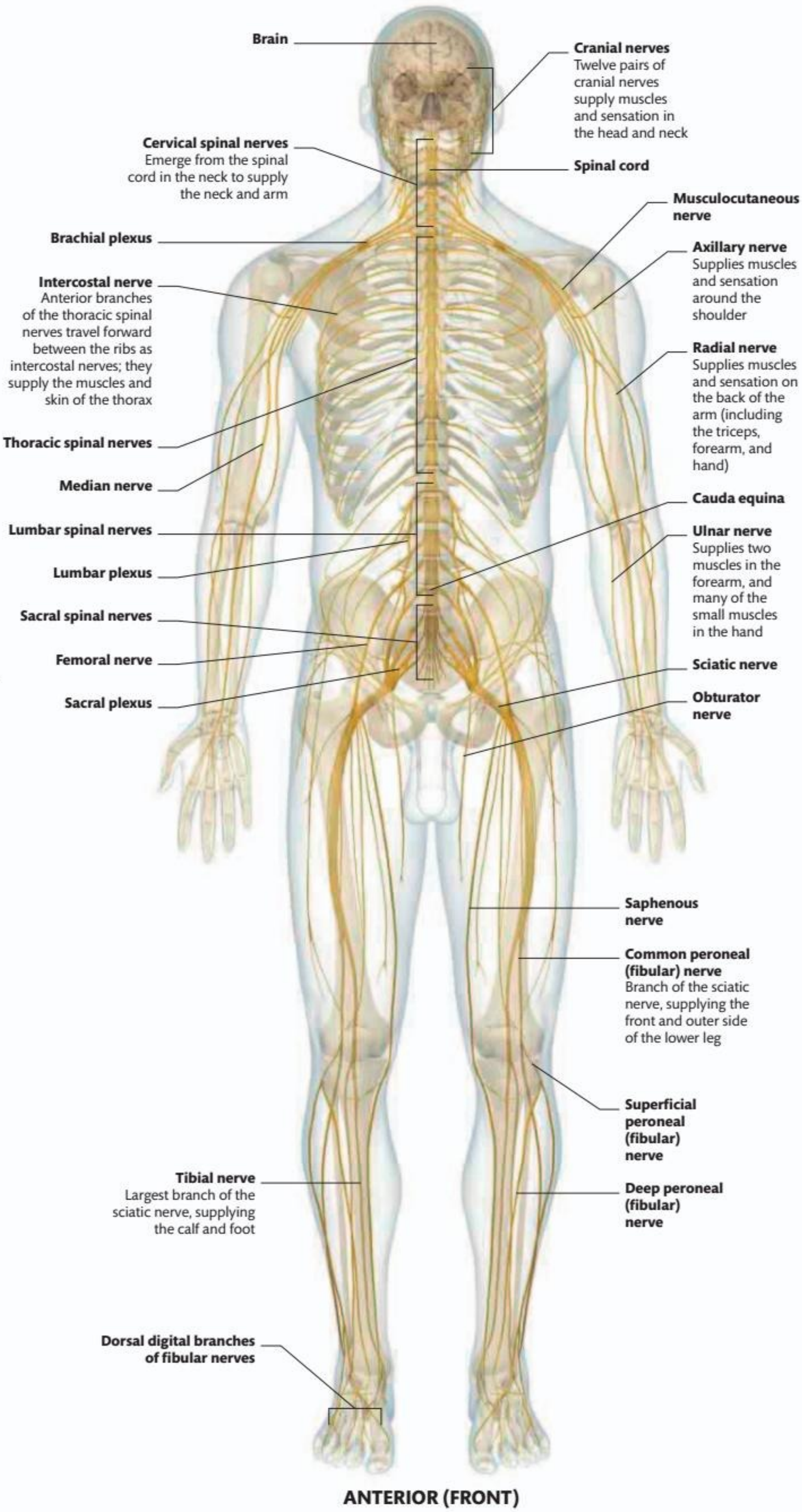
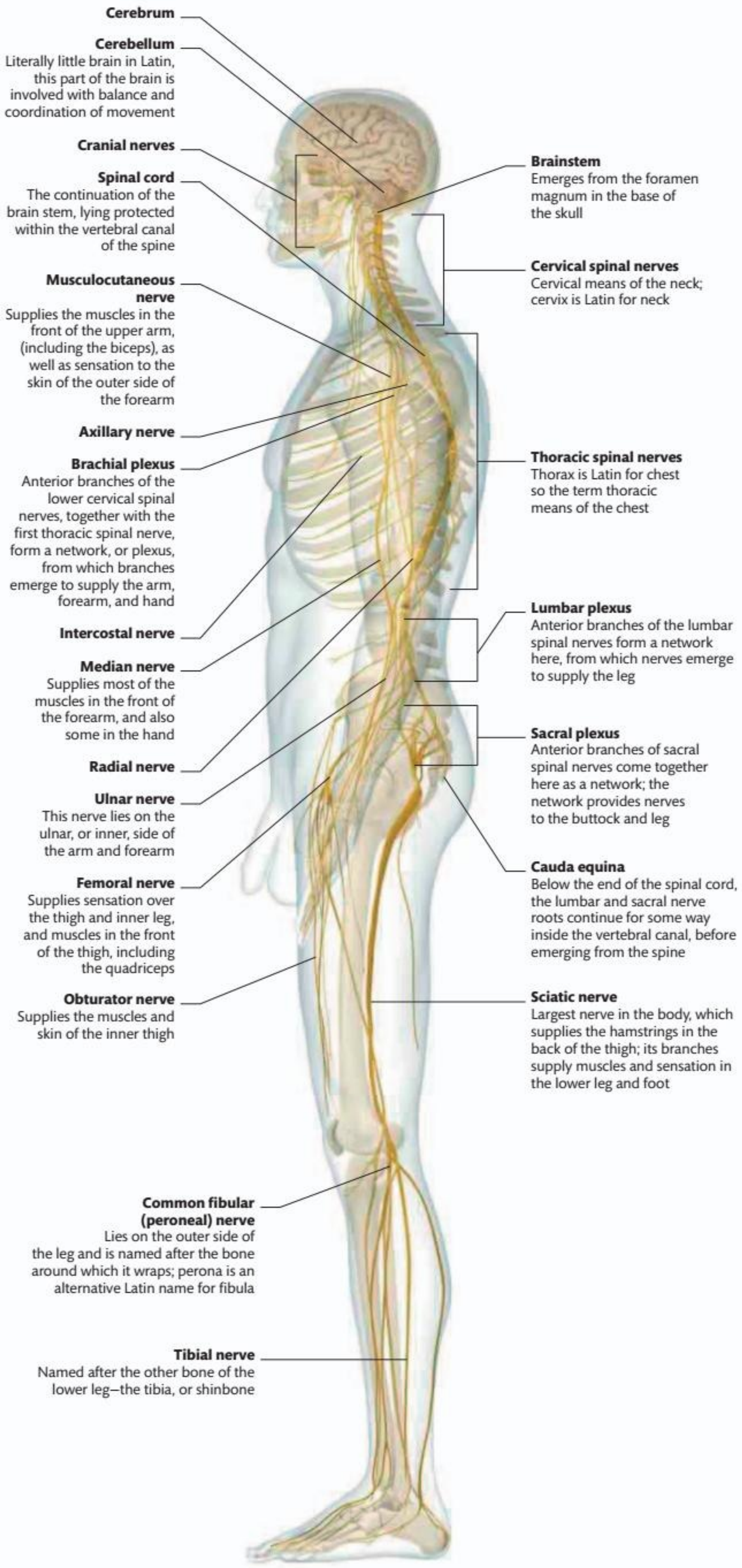
NERVOUS SYSTEM **OVERVIEW**

The nervous system contains billions of intercommunicating nerve cells, or neurons. It can be broadly divided into the central nervous system (brain and spinal cord) and the peripheral nervous system (cranial and spinal nerves and their branches). The brain and spinal cord are protected by the skull and vertebral column respectively. Twelve cranial nerves emerge from the brain and exit through holes in the skull to supply the head and neck; thirty-one pairs of spinal nerves leave via gaps between vertebrae to supply the rest of the body. You can also divide the nervous system by function. The part that deals more with the way we sense and interact with our surroundings is called the somatic nervous system. The part involved with sensing and controlling our internal environments—affecting glands or heart rate, for example—is the autonomic nervous system.

SYMPATHETIC TRUNK



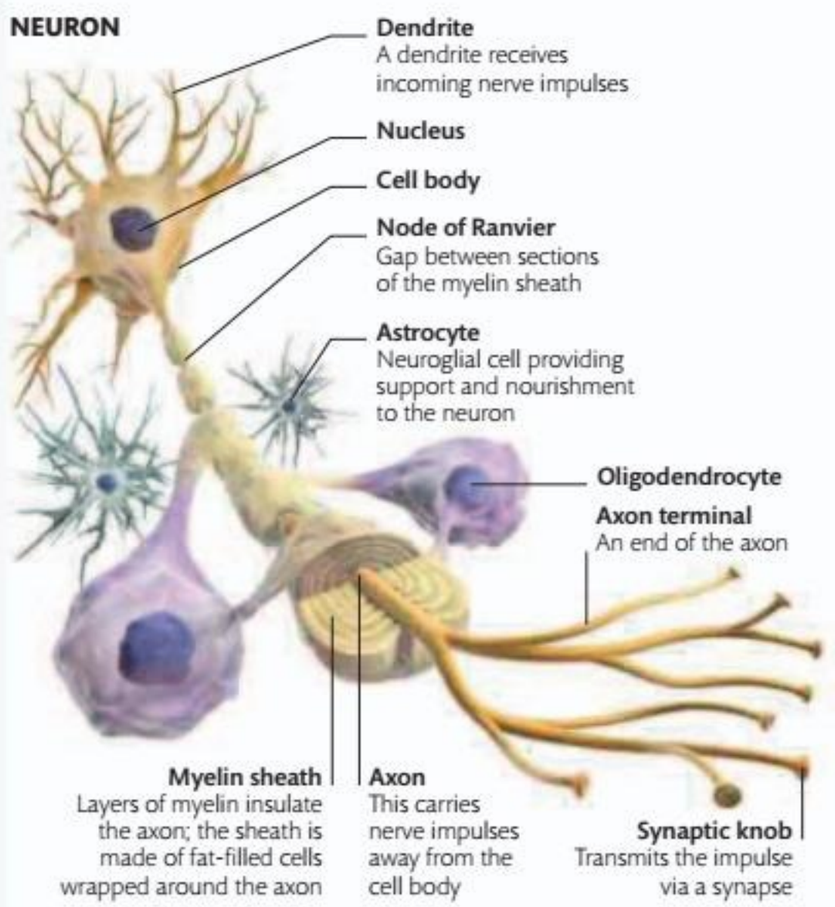
ANTERIOR (FRONT)



SIDE

NEURON STRUCTURE

A single neuron such as the cell shown below from the central nervous system can make contact with hundreds of other neurons, creating an incredibly complex network of connections. Each neuron's cell body has projections or, dendrites. One is usually longer and thinner than the rest, and this is the axon. Some axons within the brain are less than 1/32in (1mm) in length; others, stretching from the spinal cord to limb muscles, can measure over 39in (1m) long.



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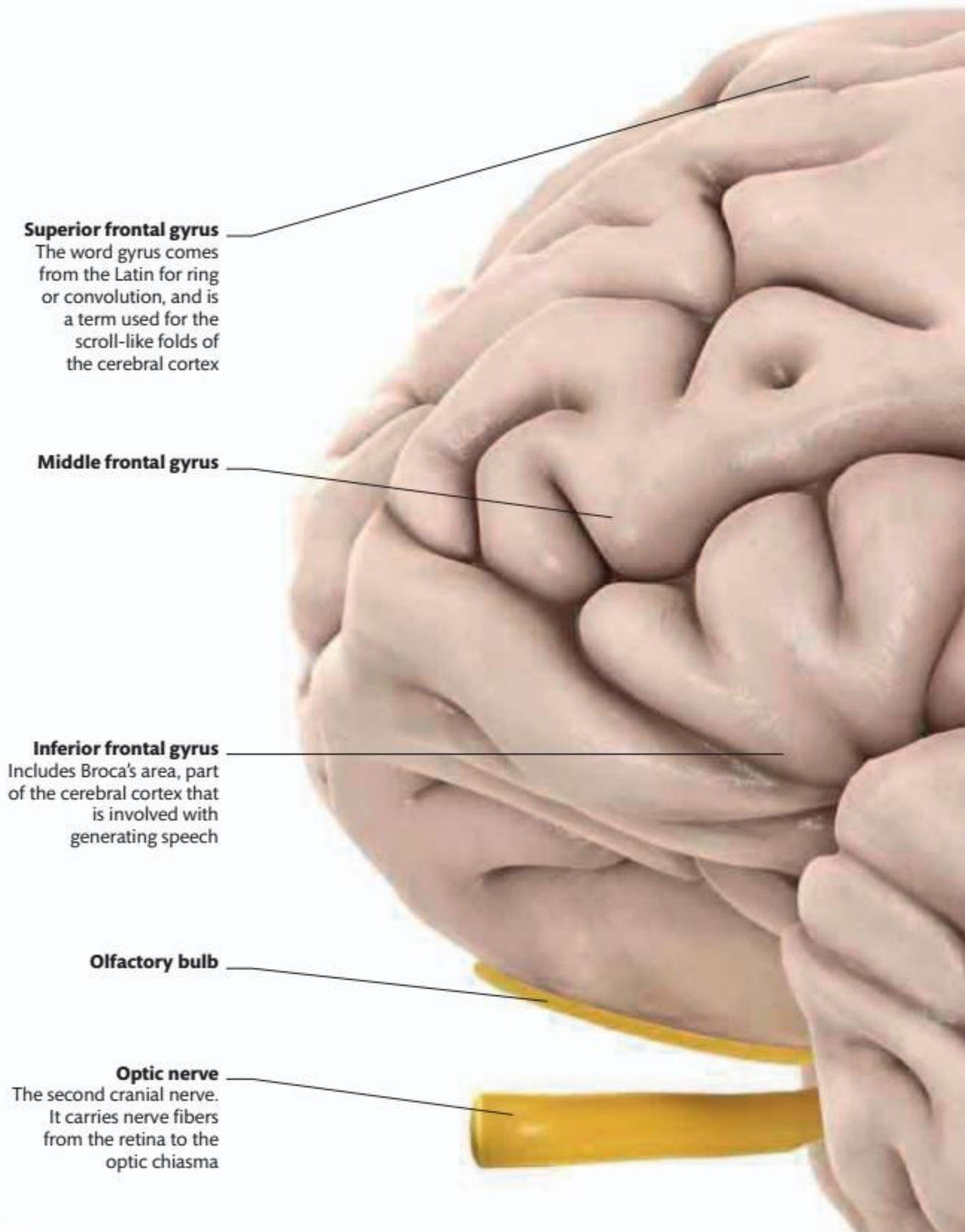
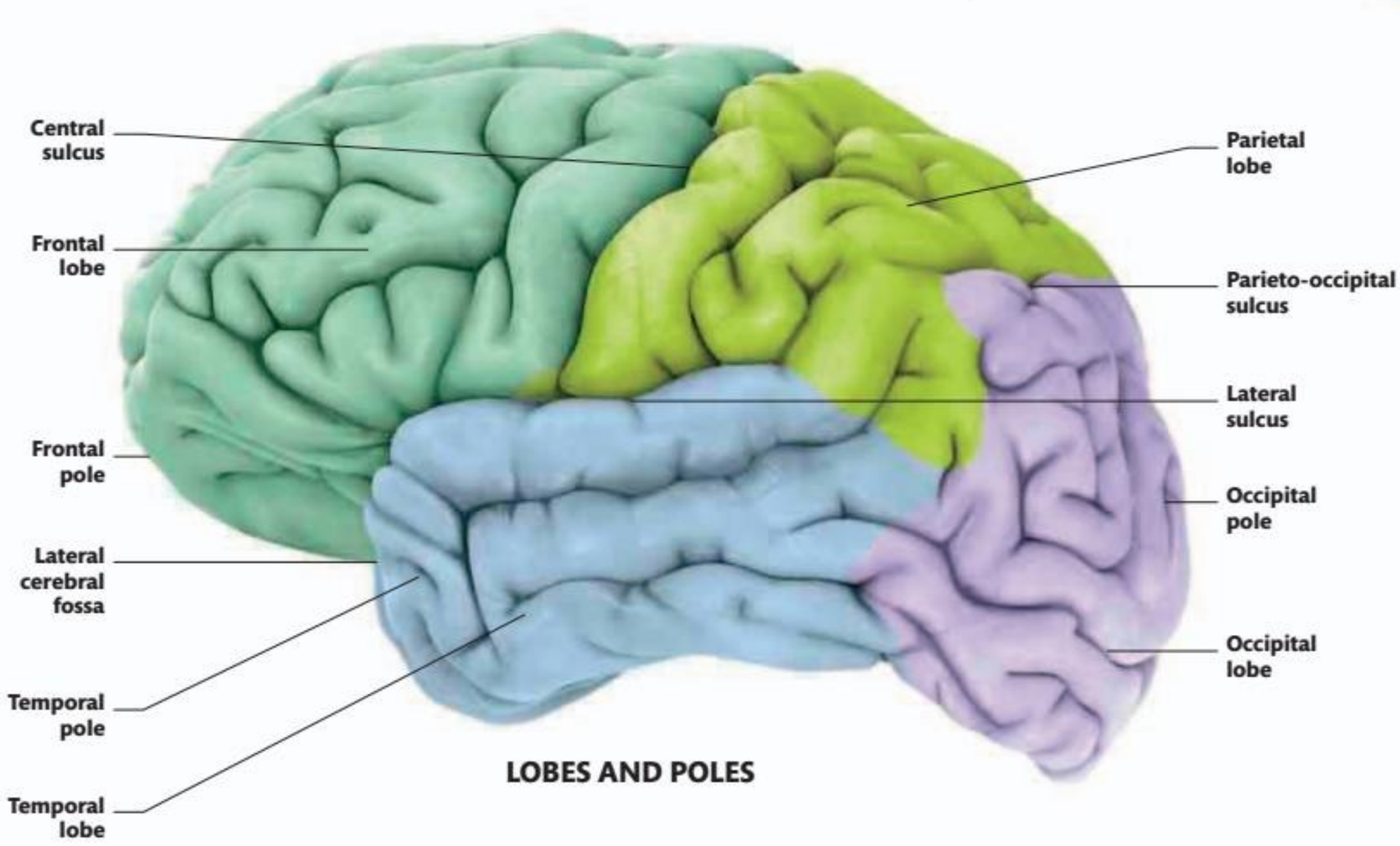
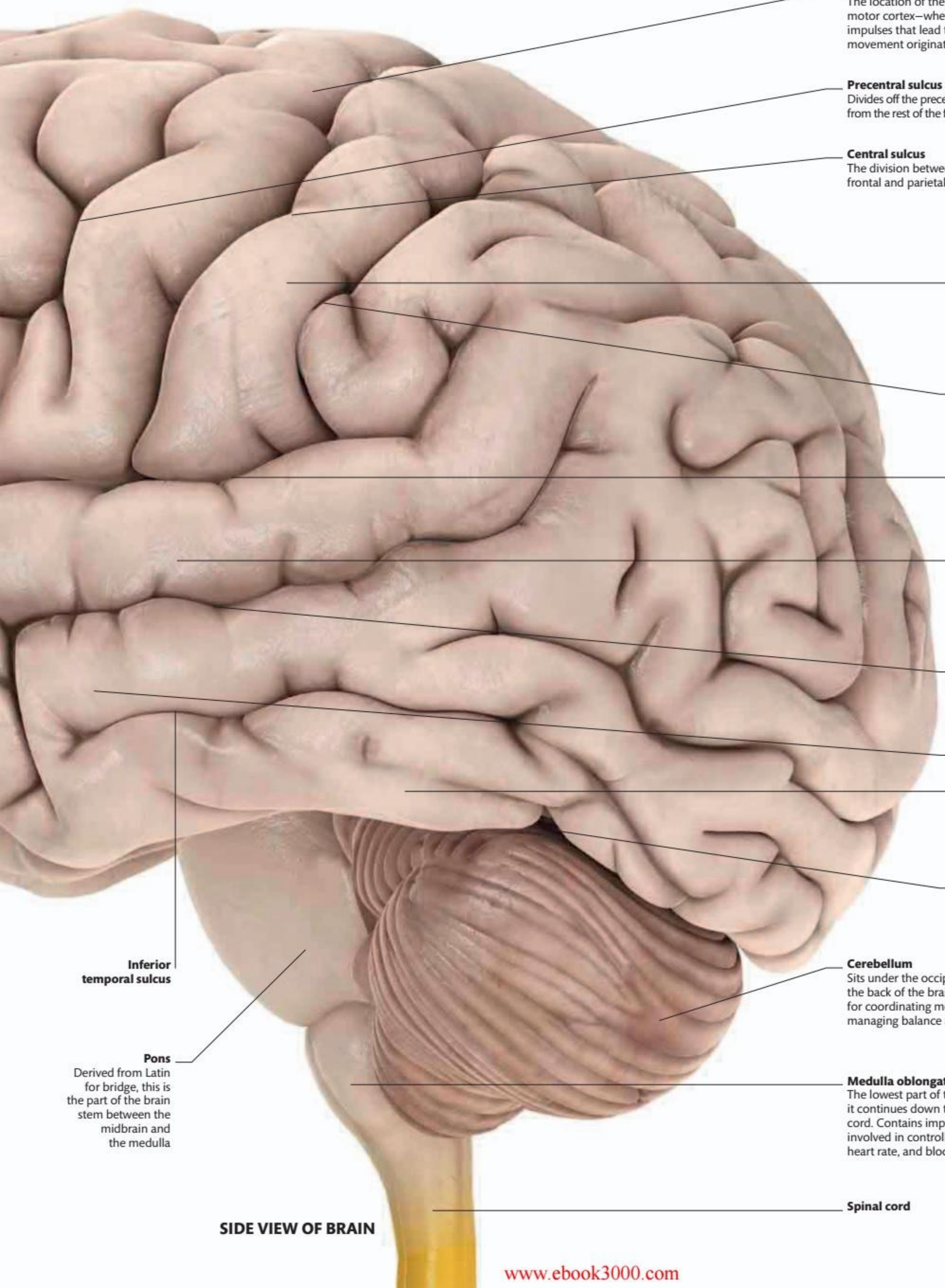
BRAIN

Compared to other animals, humans have massive brains for the size of our bodies. The human brain has grown larger and larger over the course of evolution, and it is now so overblown that the frontal lobes of the brain lie right over the top of the orbits that contain the eyes. Think about any other mammal, perhaps a dog or a cat for easy reference, and you will quickly realize what an odd shape the human head is—and most of that is a result of our huge brains. Looking at a side view of the brain, you can see all the lobes that make up each cerebral hemisphere: the frontal, parietal, temporal, and occipital lobes (individually colored, below). Tucked under the cerebral hemispheres at the back of the brain is the cerebellum (Latin for little brain). The brain stem leads down, through the foramen magnum of the skull, to the spinal cord.





LOBES AND POLES



Precentral gyrus
The location of the primary motor cortex—where nerve impulses that lead to muscle movement originate

Precentral sulcus
Divides off the precentral gyrus from the rest of the frontal lobe

Central sulcus
The division between the frontal and parietal lobes

Postcentral gyrus
Lies just behind the central sulcus. The primary somatosensory cortex, which receives sensory information from all over the body

Postcentral sulcus
Separates the postcentral gyrus from the rest of the parietal lobe

Lateral sulcus
A deep cleft dividing the frontal and parietal lobes from the temporal lobe below

Superior temporal gyrus
Includes the primary auditory cortex, where sensory information related to hearing is received

Superior temporal sulcus
Sulcus is a Latin word meaning groove or furrow

Middle temporal gyrus

Inferior temporal gyrus

Preoccipital notch

Inferior temporal sulcus

Cerebellum
Sits under the occipital lobes at the back of the brain; responsible for coordinating movement and managing balance and posture

Pons
Derived from Latin for bridge, this is the part of the brain stem between the midbrain and the medulla

Medulla oblongata
The lowest part of the brain stem; it continues down to form the spinal cord. Contains important centers involved in controlling breathing, heart rate, and blood pressure

Spinal cord

SIDE VIEW OF BRAIN

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BRAIN

From an anatomist's point of view, the brain is quite an ugly and unprepossessing organ. It looks rather like a large, pinkish gray, wrinkled walnut—especially when viewed from above. The outer layer of gray matter, called the cortex, is highly folded. Underneath the brain we see some more detail, including some of the cranial nerves that emerge from the brain itself. To the naked eye, there is little to suggest that the brain is the most complicated organ in the human body. Its true complexity is only visible through a microscope, revealing billions of neurons that connect with each other to form the pathways that carry our senses, govern our actions, and create our minds.

Longitudinal (cerebral) fissure
A deep cleft dividing the two cerebral hemispheres

Middle frontal gyrus

Inferior frontal gyrus

Precentral sulcus

Precentral gyrus

Postcentral gyrus

Central sulcus

Supramarginal gyrus
Many parts of the cortex are "association areas", involved with processing sensory information and perception. This gyrus, on the left, has been shown to be important in understanding spoken language, learning new vocabulary, and reading

Postcentral sulcus

Occipital pole

Frontal pole

Superior frontal sulcus

Inferior frontal sulcus

Superior frontal gyrus

Cingulate sulcus

Superior parietal lobule

Intraparietal sulcus
Divides the superior from the inferior parietal lobule

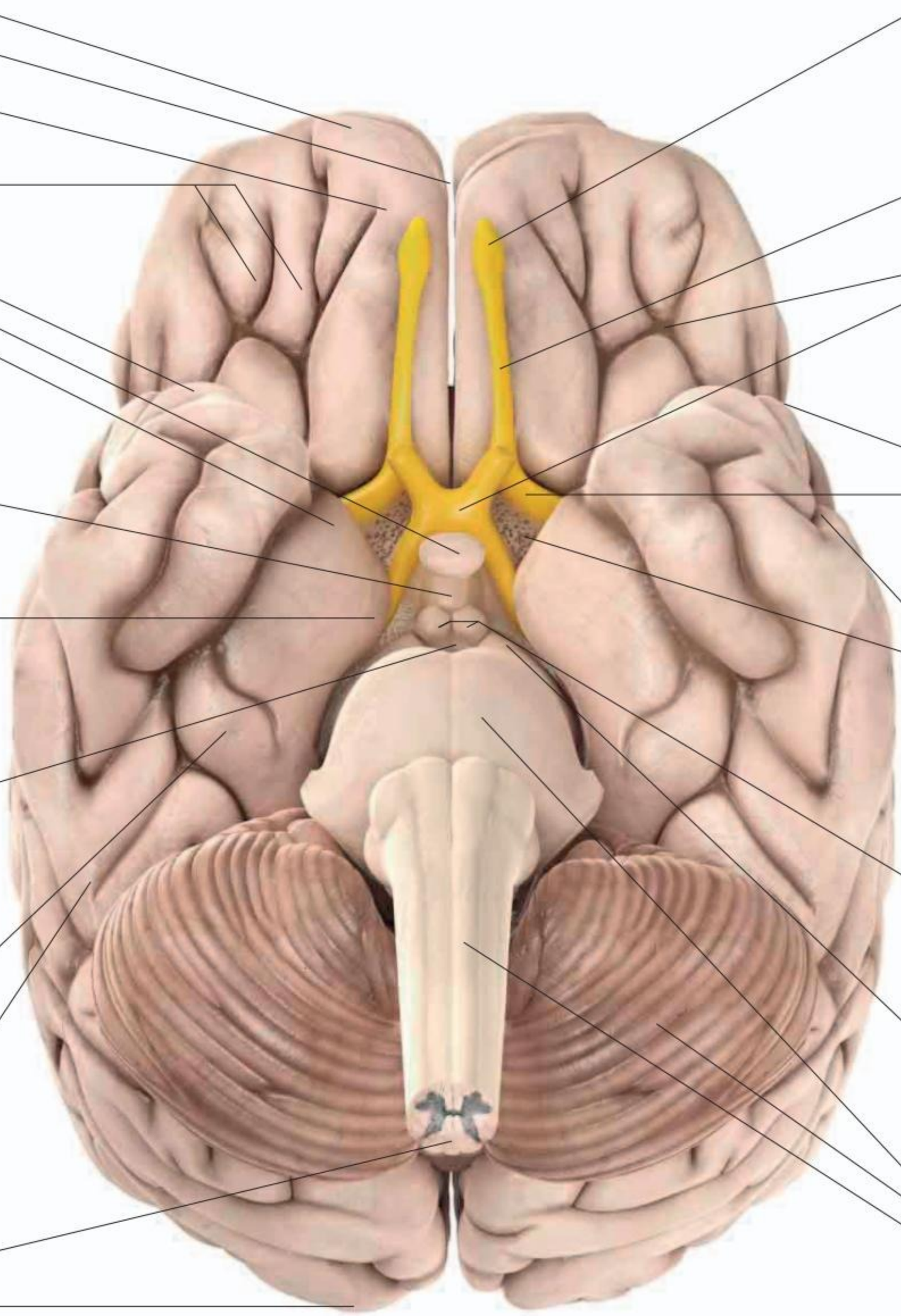
Superior temporal sulcus

Angular gyrus
Turns a corner around the end of the superior temporal sulcus. Studies of brain function suggest this area may be important in mathematical problem-solving and understanding metaphors

Inferior parietal lobule

Parieto-occipital sulcus
Divides the parietal and occipital lobes

TOP VIEW OF BRAIN



Frontal pole

Longitudinal (cerebral) fissure

Straight gyrus

Orbital gyri
Lie around the edges of the H-shaped orbital sulcus, and seem to play some role in empathy

Temporal pole

Pituitary gland

Parahippocampal gyrus
This part of the cortex, close to the hippocampus, plays an important role in memory and recognition

Tuber cinereum
Small bump of gray matter under the brain; part of the hypothalamus (see p.116)

Uncus
Hooked-under end of the parahippocampal gyrus; contains the primary olfactory cortex, receiving olfactory (smell) information

Interpeduncular fossa
Area enclosed by the cerebral peduncles on each side, by the optic chiasma in front, and the pons of the brain stem behind

Occipitotemporal fusiform gyrus

Inferior temporal gyrus

Spinal cord

Occipital pole

Olfactory bulb
Receives olfactory nerves, which have emerged from the top of the nasal cavity through the cribiform plate of the ethmoid bone, to enter the inside of the skull

Olfactory tract
Carries olfactory (smell) information back to the uncus

Orbital sulcus

Optic chiasma
Where the two optic nerves meet and swap fibers with each other, to form the optic tracts; chiasma means a cross

Lateral cerebral fossa

Olfactory trigone
The olfactory tract splays out into this triangular shape, just in front of the anterior perforated substance

Inferior temporal sulcus

Anterior perforated substance
Area of gray matter between the olfactory trigone, the optic chiasma, and the uncus; pierced by small arteries from the anterior and middle cerebral arteries

Mammillary bodies
Two breast-like bumps that are part of the limbic system, which is involved in memory, emotions, and behavior

Cerebral peduncle
"Stalk" of the brain, containing motor nerve fibers that descend from the cerebral cortex to the brain stem and spinal cord

Pons

Cerebellum

Pyramid
A prominence on the front of medulla containing motor nerve fibers that run from the cortex of the brain to the spinal cord

UNDERSIDE OF BRAIN

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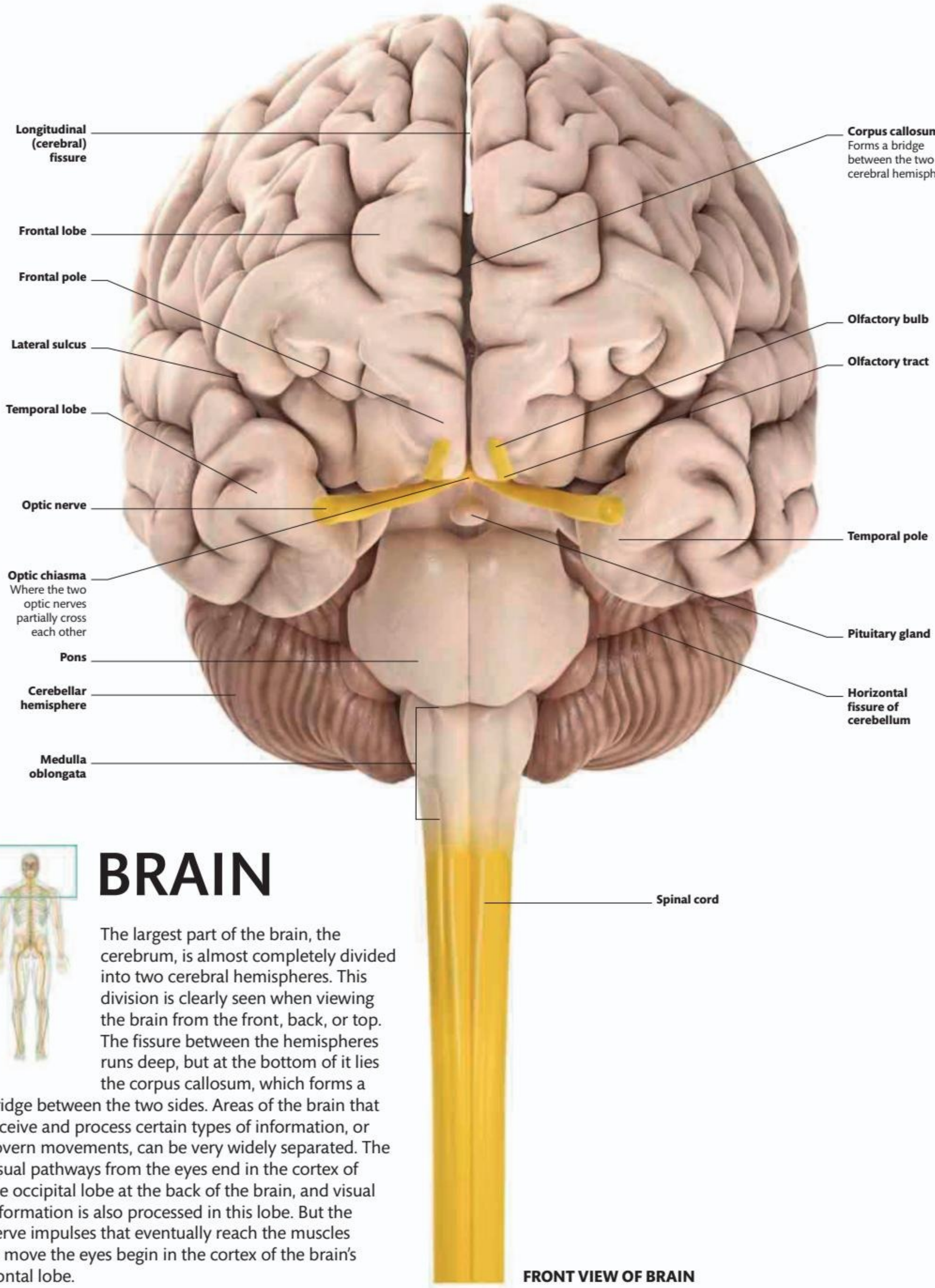
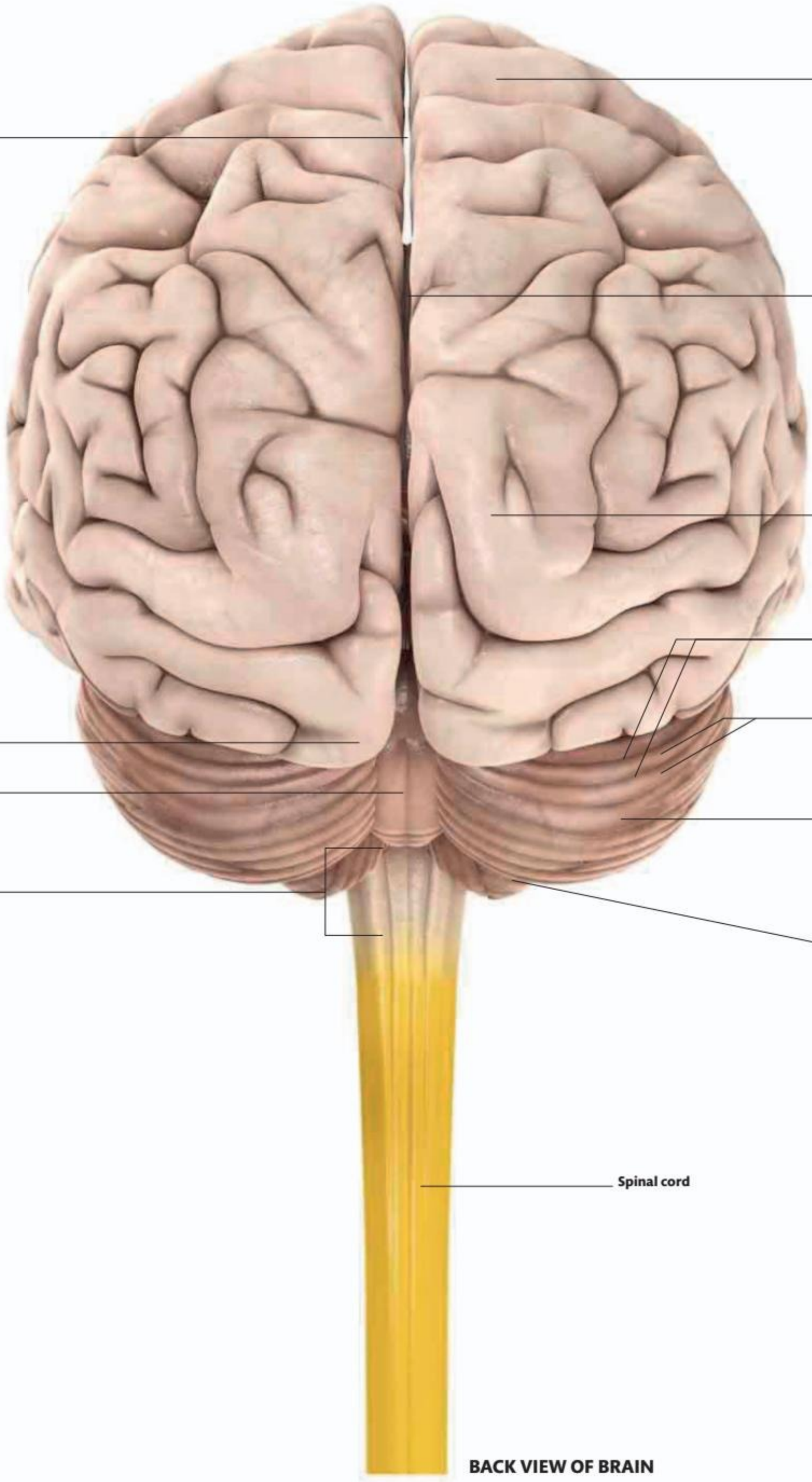


FRONT VIEW OF BRAIN

BRAIN

The largest part of the brain, the cerebrum, is almost completely divided into two cerebral hemispheres. This division is clearly seen when viewing the brain from the front, back, or top. The fissure between the hemispheres runs deep, but at the bottom of it lies the corpus callosum, which forms a bridge between the two sides. Areas of the brain that receive and process certain types of information, or govern movements, can be very widely separated. The visual pathways from the eyes end in the cortex of the occipital lobe at the back of the brain, and visual information is also processed in this lobe. But the nerve impulses that eventually reach the muscles to move the eyes begin in the cortex of the brain's frontal lobe.



BACK VIEW OF BRAIN

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Body of corpus callosum
The largest commissure (or bundle of connecting nerve fibers) between the two hemispheres, this forms the roofs of the lateral ventricles

Superior frontal gyrus

Cingulate gyrus
Cingulum is the Latin for girdle and this gyrus wraps closely around the corpus callosum; it is part of the limbic system, which is involved with emotional responses and behaviors

Septum pellucidum
This translucent partition is a thin dividing wall between the two lateral ventricles

Genu of corpus callosum
The anterior (front) end of the corpus callosum is bent over—genu means knee in Latin

Anterior commissure
A bundle of nerve fibers connecting parts of the two cerebral hemispheres

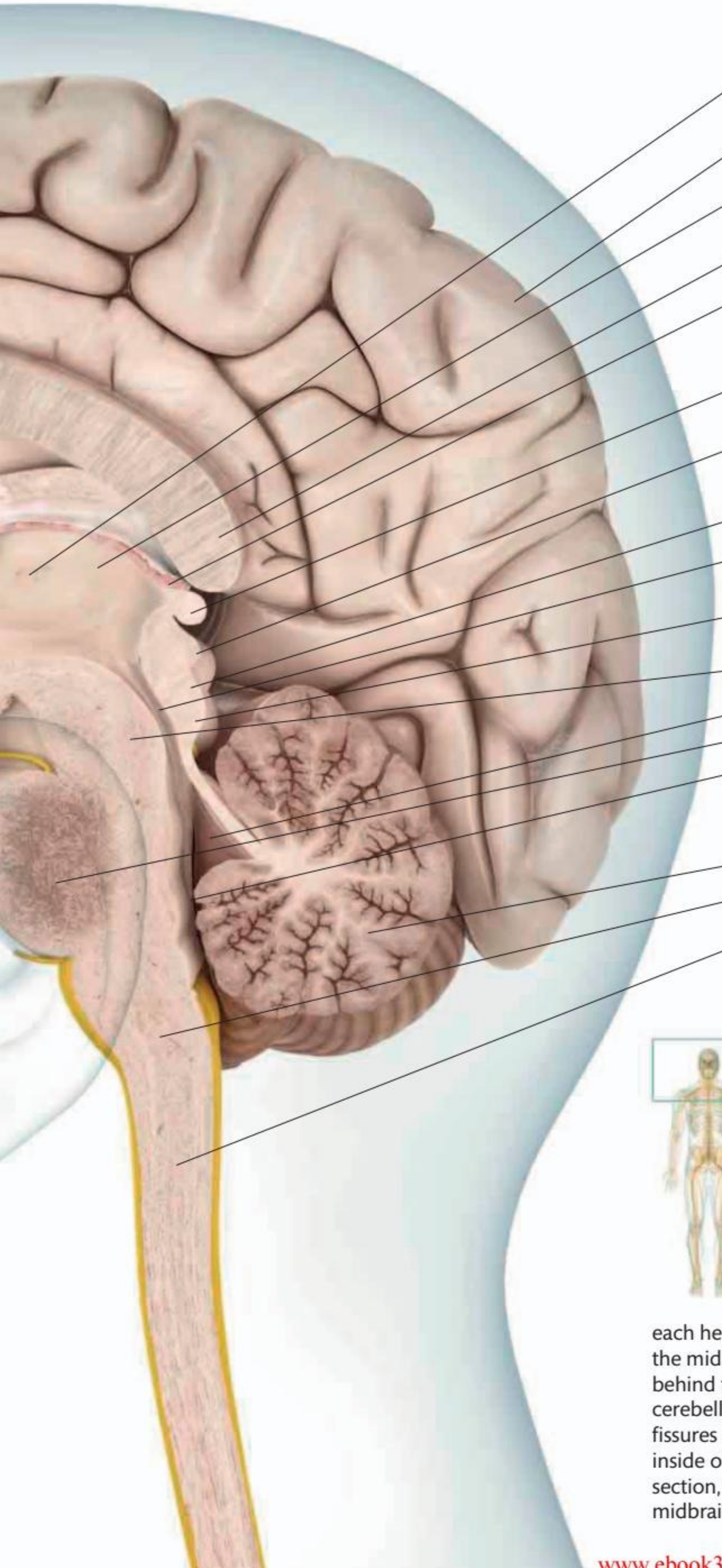
Optic chiasma
The crossover point where the two optic nerves meet and swap fibers, then part company as the optic tracts, which continue on each side of the brain toward the thalamus

SAGITTAL SECTION THROUGH BRAIN

Hypothalamus
Plays an important role in regulating the internal environment of the body, by keeping a check on body temperature, blood pressure, and blood sugar level, for instance

Pituitary gland
Produces many hormones and forms a link between the brain and endocrine system

Mammillary body
Part of the limbic system of the brain



Interthalamic adhesion
Connection between the thalami on each side of the brain

Cerebrum
The largest part of the brain, consisting of the two cerebral hemispheres

Thalamus
Processes and relays sensory and motor information to higher brain centers

Splenium of corpus callosum
The posterior end of the corpus callosum

Choroid plexus of the third ventricle
A choroid plexus is formed where the inner and outer membranes of the brain come together; it is full of capillaries and produces cerebrospinal fluid, which flows into the ventricle

Pineal gland
Produces the hormone melatonin and is involved in the regulation of sleep–wake cycles

Superior colliculus
Involved in visual reflex pathways, including the pupillary light reflex, which makes the pupils constrict when bright light hits the retina

Tectum of the midbrain
The roof of the midbrain

Cerebral aqueduct
A narrow channel connecting the third and fourth ventricles

Inferior colliculus
Involved with auditory pathways, including reflex responses to loud noises

Tegmentum of midbrain

Fourth ventricle

Pons

Median aperture of the fourth ventricle
Cerebrospinal fluid escapes from the fourth ventricle via this opening in the midline, as well as through an opening on each side, into the subarachnoid space around the brain and spinal cord

Cerebellum

Medulla oblongata

Spinal cord

HEAD AND NECK

This median sagittal section—a vertical slice right through the middle of the brain—shows clearly the corpus callosum, which links the two hemispheres. We also see that the brain is not solid: there are cavities within it. Two spaces (or ventricles) lie inside each hemisphere, while the third and fourth ventricles are located on the midline. These spaces are full of cerebrospinal fluid. Beneath and behind the cerebrum sits the cerebellum. The gray cortex of the cerebellum is more finely folded than that of the cerebrum, with fissures separating its leaves (or folia). Sliced through this way, the inside of the cerebellum reveals a beautiful, treelike pattern. In this section, we can also see clearly all the parts of the brain stem—the midbrain, pons, and medulla.

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BRAIN

The brain is protected by three membranes called the meninges (which become inflamed in meningitis). The tough dura mater layer is the outermost covering, which surrounds the brain and the spinal cord. Under the dura mater is the cobweblike arachnoid mater layer. The delicate pia mater is a thin membrane on the surface of the brain. Between the pia mater and the arachnoid mater there is a slim gap—the subarachnoid space—which contains cerebrospinal fluid (CSF). Mainly produced by the choroid plexus in the brain's lateral ventricles, CSF flows through the third ventricle into the fourth, where it can escape via small apertures into the subarachnoid space.

Anterior horn of lateral ventricle

Septum pellucidum

Caudate nucleus
Part of the basal ganglia, this "tailed" nucleus helps to control and smooth out movement

Fornix
A fibrous arch connecting the mammillary bodies to the hippocampus; the fornix is part of the limbic system

Splenium of corpus callosum

Inferior horn of lateral ventricle

Genu of corpus callosum

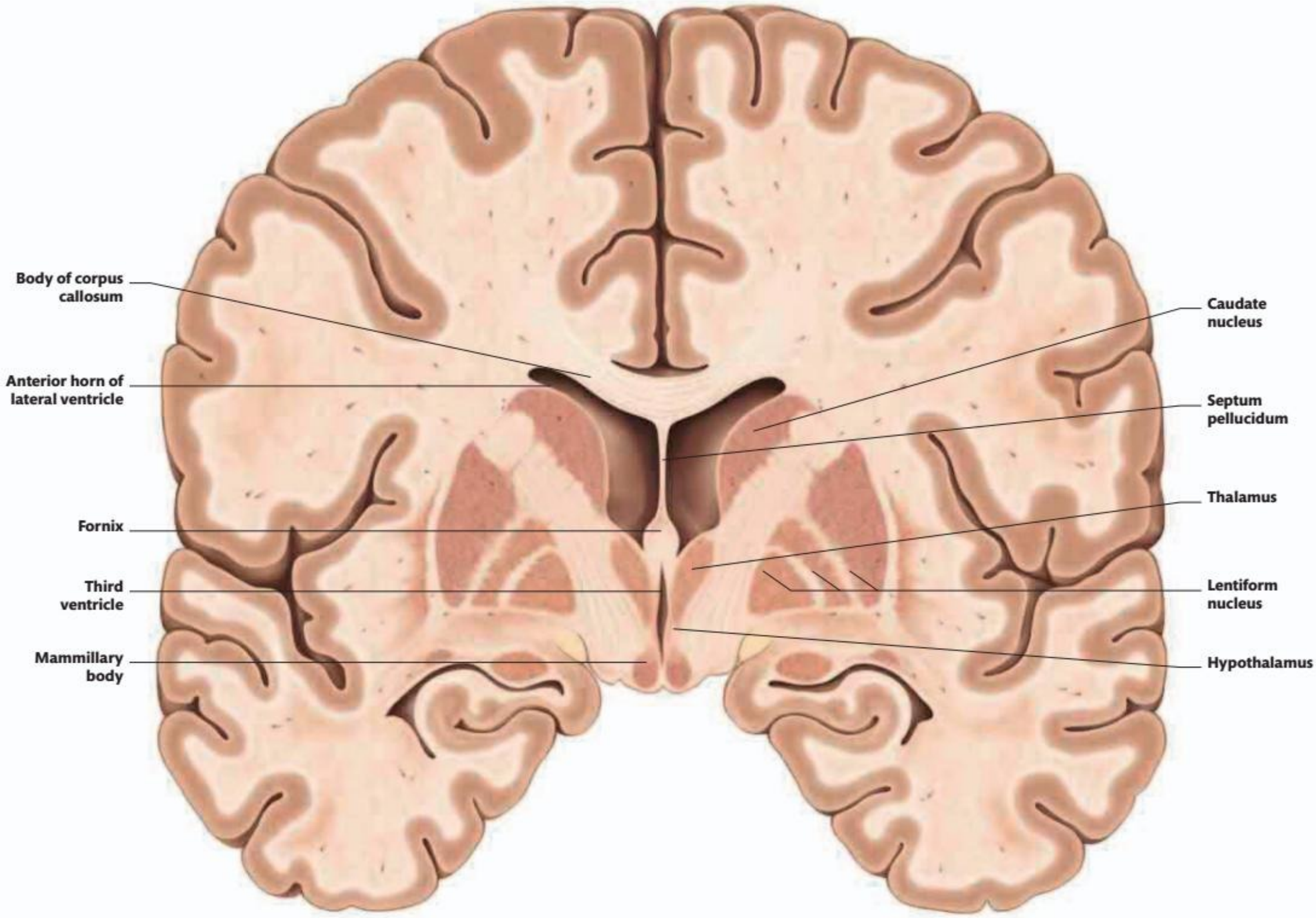
Internal capsule
Area that contains many motor nerve fibers, descending from the motor cortex and heading for the brain stem and spinal cord

Lentiform nucleus
Another part of the basal ganglia; lentiform means lentil shaped

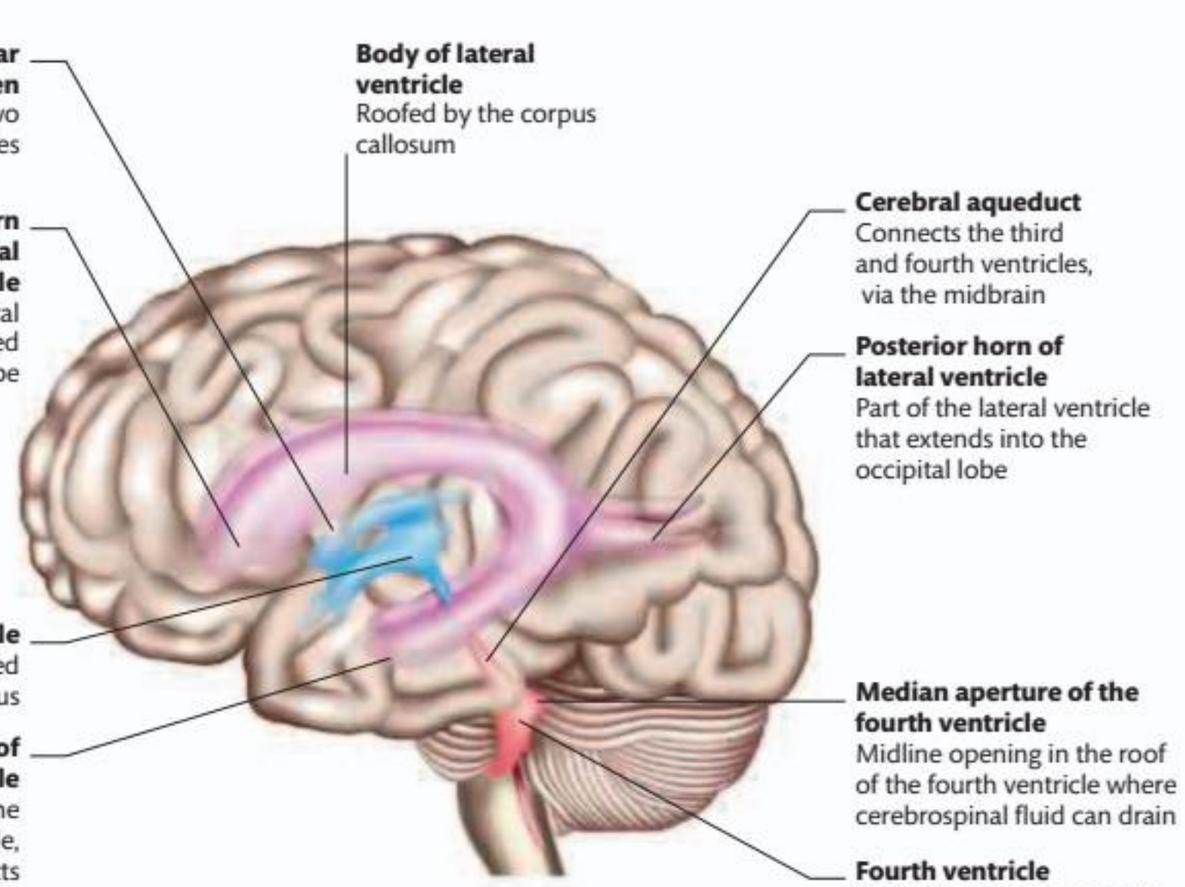
Thalamus
Egg-shaped structure flanking the third ventricle; this is a major relay station for both motor and sensory fibers leaving and entering the brain

Optic radiation
Part of the visual pathway where nerve fibers fan out to reach the visual cortex in the occipital lobe

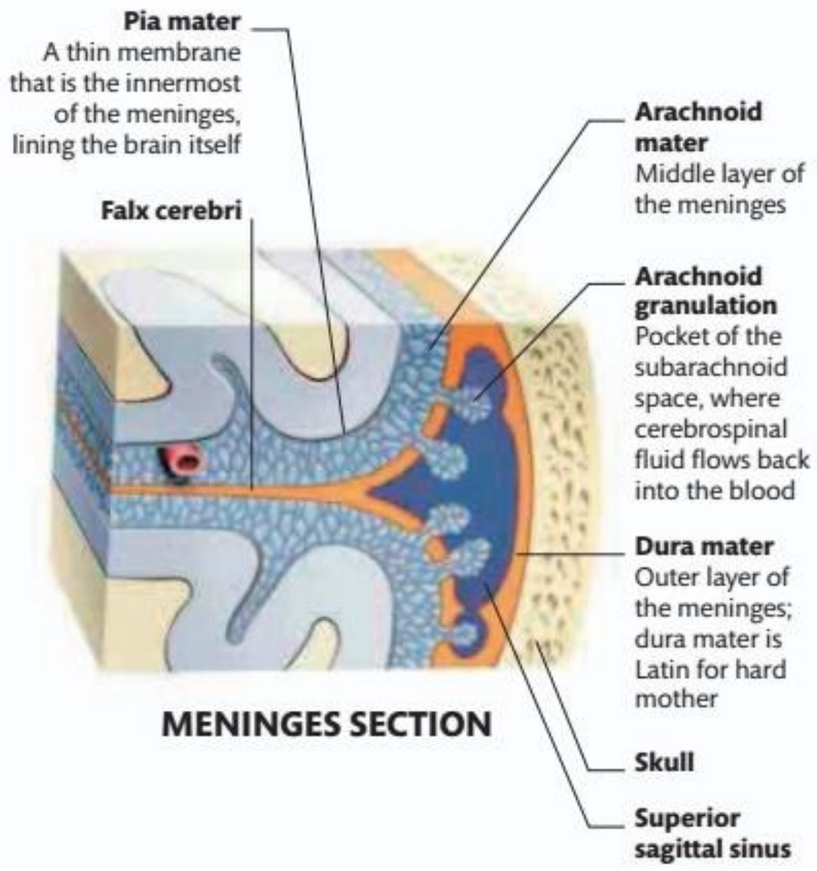
TRANSVERSE SECTION OF BRAIN



CORONAL SECTION OF BRAIN



VENTRICLES OF BRAIN



MENINGES SECTION

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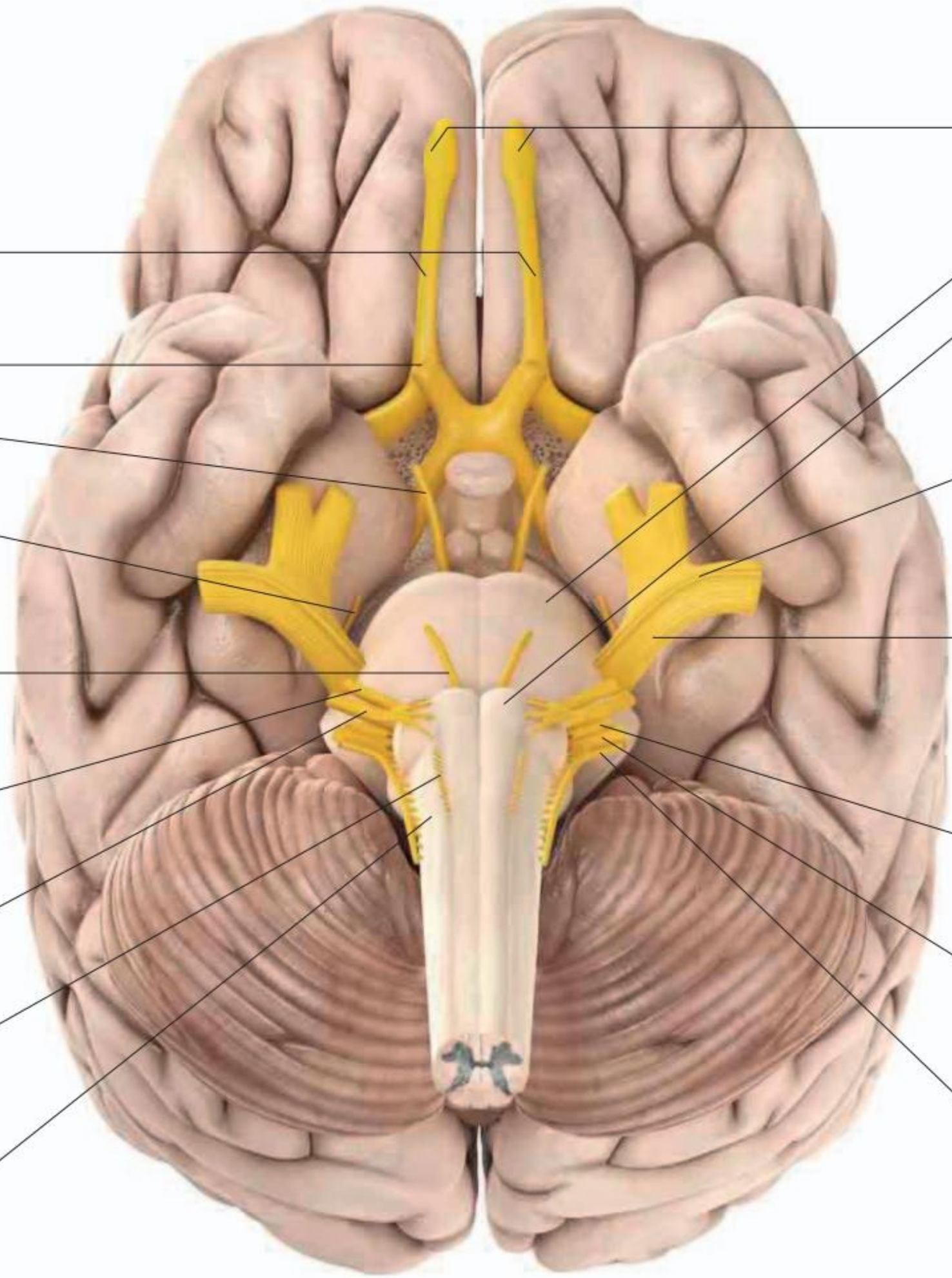
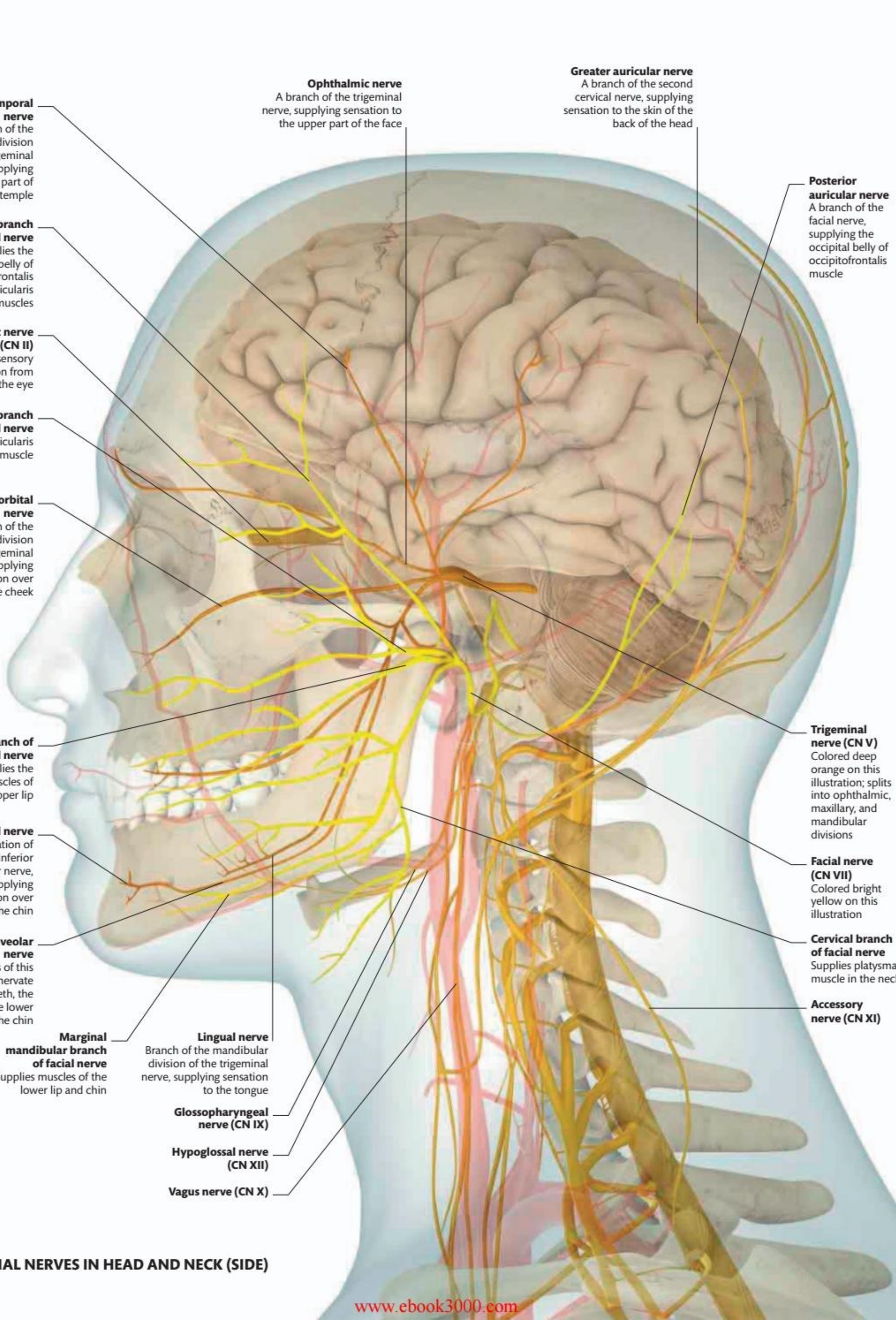
HEAD AND NECK

The 12 pairs of cranial nerves (the standard abbreviation for which is CN) emerge from the brain and brain stem, leaving through holes, or "foramina", in the base of the skull. Some nerves are purely sensory, some just have motor functions, but most contain a mixture of motor and sensory fibers. A few also contain autonomic nerve fibers. The olfactory nerve and the optic nerve attach to the brain itself. The other 10 pairs of cranial nerves emerge from the brain stem. All the cranial nerves supply parts of the head and neck, except the vagus nerve. This has branches in the neck, but then continues on to supply organs in the thorax and down to the abdomen. Careful testing of cranial nerves, including tests of sight, eye and head movement, taste, and so on, can help doctors to pinpoint neurological problems in the head and neck.



ORIGIN OF CRANIAL NERVES (UNDERSIDE OF BRAIN)



Auriculotemporal nerve
Branch of the mandibular division of the trigeminal nerve, supplying sensation to part of the ear and temple

Temporal branch of facial nerve
Supplies the frontal belly of occipitofrontalis and orbicularis oculi muscles

Optic nerve (CN II)
Carries sensory information from the retina of the eye

Zygomatic branch of facial nerve
Supplies orbicularis oculi muscle

Infraorbital nerve
Branch of the maxillary division of the trigeminal nerve, supplying sensation over the cheek

Buccal branch of facial nerve
Supplies the muscles of the upper lip

Mental nerve
Continuation of the inferior alveolar nerve, supplying sensation over the chin

Inferior alveolar nerve
Branches of this nerve innervate the lower teeth, the gums, the lower lip, and the chin

Marginal mandibular branch of facial nerve
Supplies muscles of the lower lip and chin

Ophthalmic nerve
A branch of the trigeminal nerve, supplying sensation to the upper part of the face

Lingual nerve
Branch of the mandibular division of the trigeminal nerve, supplying sensation to the tongue

Glossopharyngeal nerve (CN IX)

Hypoglossal nerve (CN XII)

Vagus nerve (CN X)

Greater auricular nerve
A branch of the second cervical nerve, supplying sensation to the skin of the back of the head

Posterior auricular nerve
A branch of the facial nerve, supplying the occipital belly of occipitofrontalis muscle

Trigeminal nerve (CN V)
Colored deep orange on this illustration; splits into ophthalmic, maxillary, and mandibular divisions

Facial nerve (CN VII)
Colored bright yellow on this illustration

Cervical branch of facial nerve
Supplies platysma muscle in the neck

Accessory nerve (CN XI)

CRANIAL NERVES IN HEAD AND NECK (SIDE)

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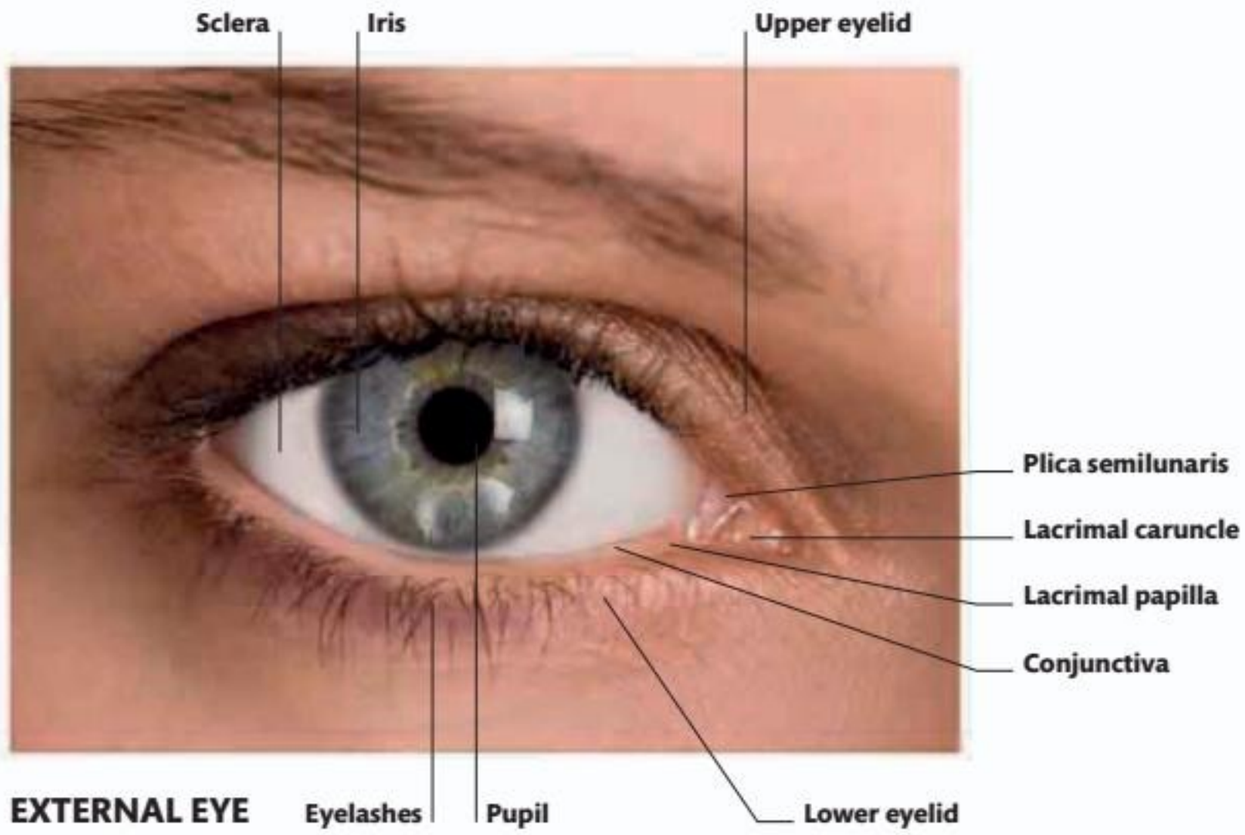
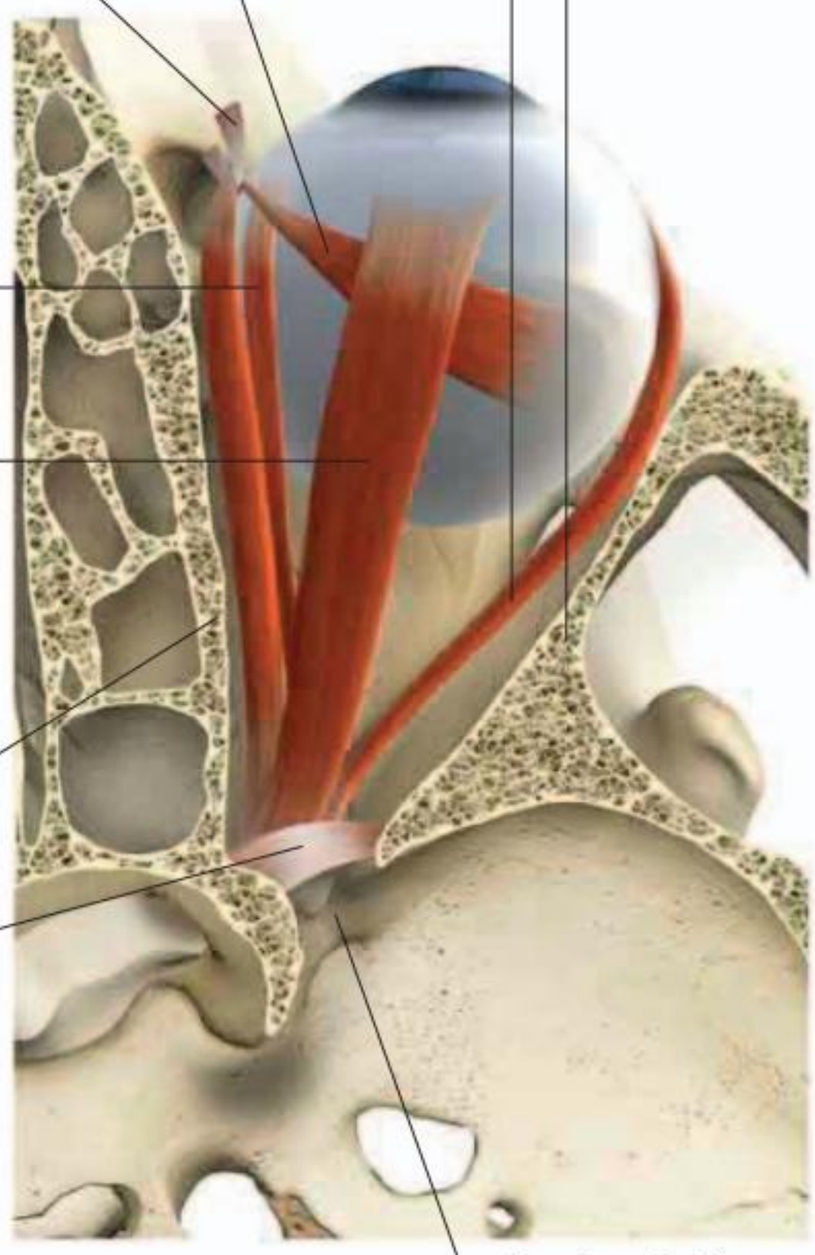
EYE

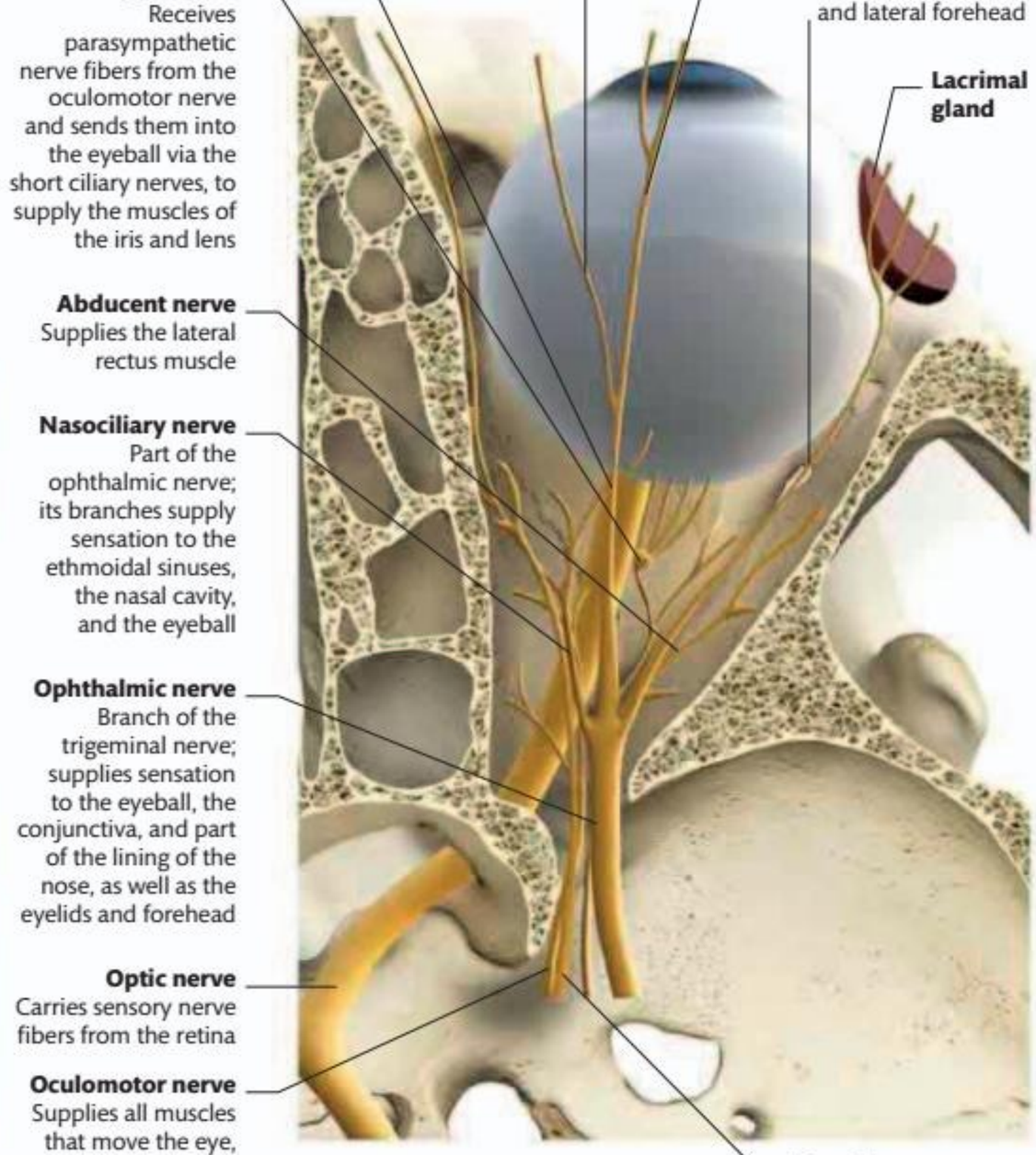
The eyes are precious organs. They are well protected inside the eye sockets, or bony orbits, of the skull. They are also protected by the eyelids, and bathed in tears produced by the lacrimal glands. Each eyeball is only 1in (2.5cm) in diameter. The orbit provides an anchor for the muscles that move the eye, and the rest of the space inside the orbit is largely filled up with fat. Holes and fissures at the back of this bony cavern transmit nerves and blood vessels, including the optic nerve, which carries sensory information from the retina to the brain. Other nerves supply the eye muscles and the lacrimal glands, and even continue on to the face to supply sensation to the skin of the eyelids and forehead.



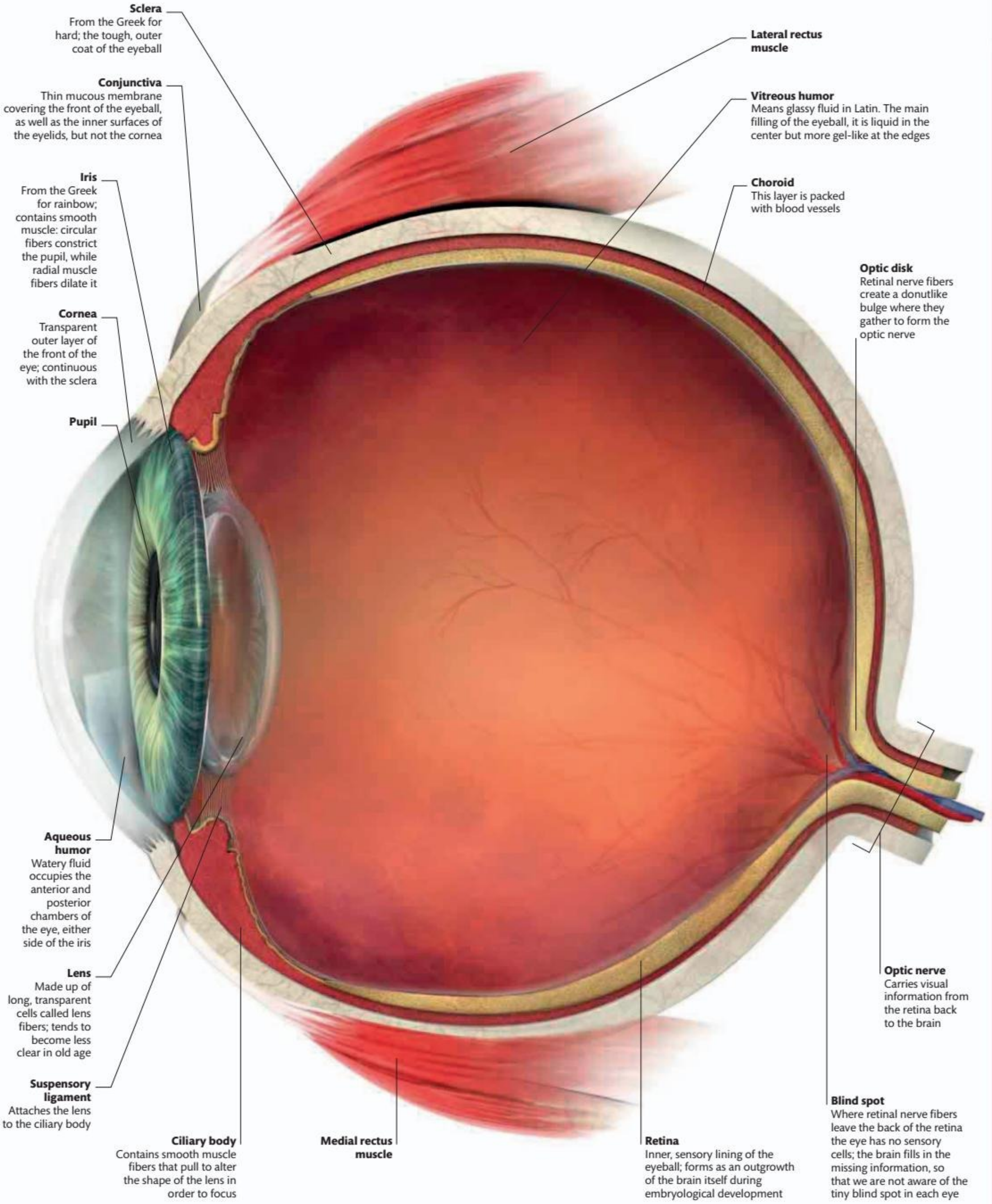
EXTERNAL EYE



MUSCLES OF THE EYE (FROM ABOVE)



NERVES OF THE ORBIT (FROM ABOVE)



HORIZONTAL SECTION THROUGH THE EYEBALL

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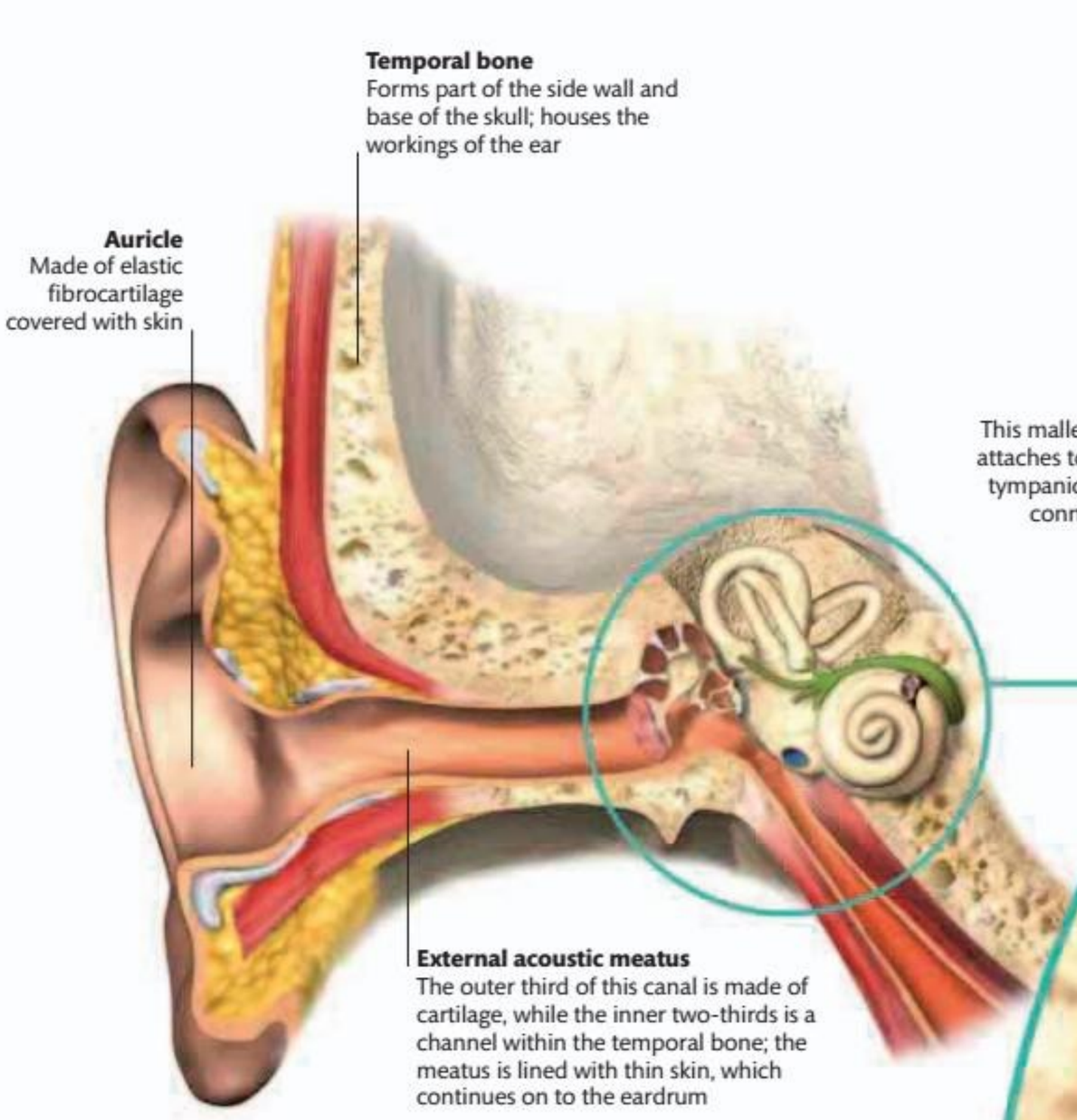
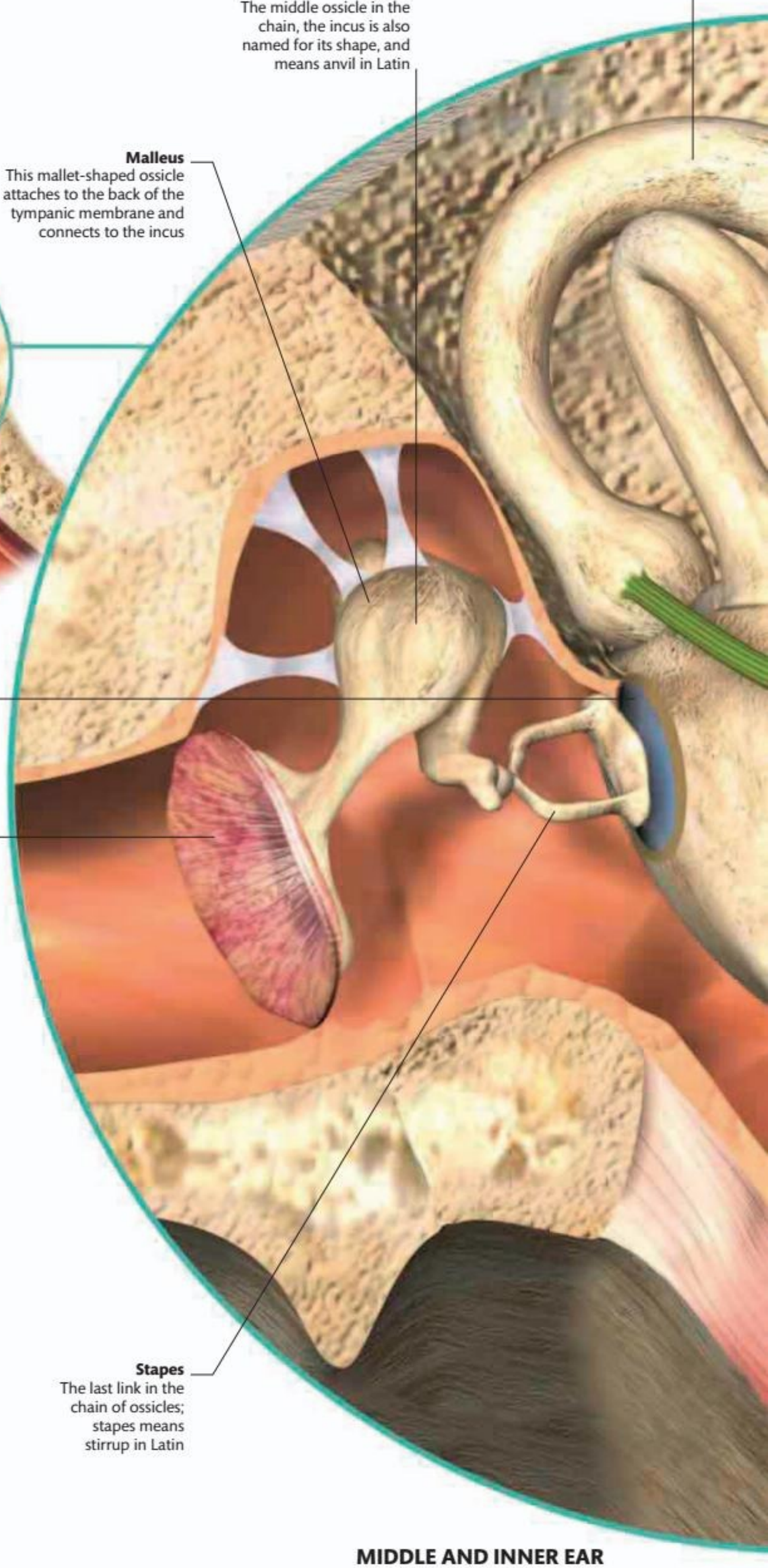


Temporal bone
Forms part of the side wall and base of the skull; houses the workings of the ear

Auricle
Made of elastic fibrocartilage covered with skin

External acoustic meatus
The outer third of this canal is made of cartilage, while the inner two-thirds is a channel within the temporal bone; the meatus is lined with thin skin, which continues on to the eardrum

EXTERNAL EAR



Posterior semicircular canal
The semicircular canals are each less than ¾in (2cm) in length, with a diameter of less than ½in (1mm); this canal is positioned vertically

Incus
The middle ossicle in the chain, the incus is also named for its shape, and means anvil in Latin

Malleus
This mallet-shaped ossicle attaches to the back of the tympanic membrane and connects to the incus

Oval window
Where the stapes attaches to the base of the cochlea, transmitting its vibrations to the fluid inside the cochlea

Tympanic membrane
The eardrum vibrates as sound waves buffet it; the ossicles (the malleus, incus, and stapes) carry those vibrations through the middle ear to the inner ear

Stapes
The last link in the chain of ossicles; stapes means stirrup in Latin

MIDDLE AND INNER EAR

EAR

The ear can be divided up into external, middle, and internal parts. The external ear includes the auricle on the outside of the head, and the external acoustic meatus—the canal that leads to the eardrum, or tympanic membrane. The middle ear is an air space inside the temporal bone. It contains the ossicles (ear bones) and is linked to the pharynx by the pharyngotympanic, or Eustachian, tube. Minute hair cells inside the inner ear convert vibrations in the fluid within the cochlea into an electrical nerve impulse. Similar hair cells in the vestibular apparatus (the semicircular canals, utricle, and saccule) convert mechanical stimuli, produced by motions of the head, into nerve impulses. The sensory nerves leaving the inner ear join to form the vestibulocochlear nerve.

Lateral semicircular canal
This is positioned horizontally

Anterior semicircular canal
Positioned vertically, but at right angles to the plane of the posterior semicircular canal

Vestibular nerve
Carries sensory information from the vestibular apparatus–including the semicircular canals

Cochlear nerve
Conveys sensory information about sound from the cochlea

Section cut from cochlea
From top to bottom shows vestibular canal, cochlear duct, and tympanic canal

Vestibulocochlear nerve
The cochlear nerve conveys sensory information about sound from the cochlea. It joins the vestibular nerve to the vestibulocochlear nerve

Cochlea
Not surprisingly, cochlea means snail in Latin

Vestibule
Contains the utricle and saccule, organs of balance

Round window
Vibrations can travel in the fluid inside the cochlea, all the way up to its apex and back down to the round window

Pharyngotympanic tube
Passage connecting the middle ear to the back of the throat, and allowing air pressure either side of the eardrum to be equalized

Helix
The outer rim of the auricle

External acoustic meatus

Antihelix
A curved prominence, parallel to the helix

Concha
This hollow is named after the Greek for shell

Tragus
This little flap overlaps the external acoustic meatus

Intertragic notch

Lobule

Antitragus
A small tubercle opposite the tragus

AURICLE

Tympanic membrane
As seen with an otoscope, a healthy eardrum has a pearly, almost translucent appearance

Lateral process of malleus

Handle of malleus

Cone of light
Light is reflected in the front, lower quadrant of the eardrum

EARDRUM

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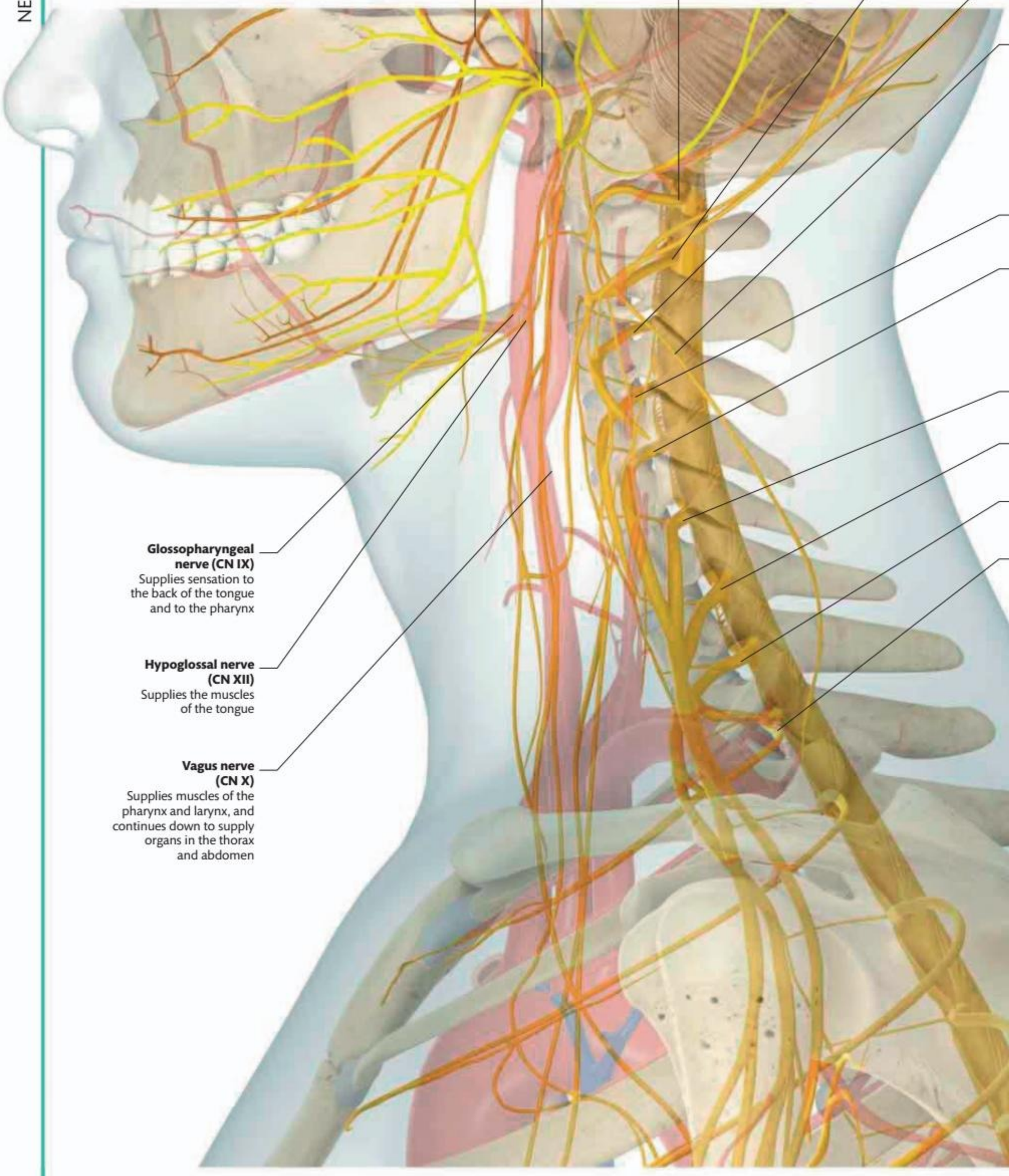


Mandibular division of trigeminal nerve (CN V)

Facial nerve (CN VII)

First cervical nerve (C1)
The very first spinal nerve; its branches supply some muscles in the upper neck

Second cervical nerve (C2)
Along with C3 and C4, this nerve supplies sensation to the skin of the neck as well as supplying a range of muscles in the neck

Third cervical nerve (C3)

Accessory nerve (CN XI)
Originates outside the skull but enters it and then comes back out; part of it joins the vagus, the remaining fibers continue into the neck to supply trapezius and sterno-cleidomastoid muscles

Fourth cervical nerve (C4)

Fifth cervical nerve (C5)
Together with C6, C7, C8 and T1, part of this nerve will form the brachial plexus—the network of nerves supplying the arm

Sixth cervical nerve (C6)

Seventh cervical nerve (C7)

Eighth cervical nerve (C8)

First thoracic nerve (T1)

Glossopharyngeal nerve (CN IX)
Supplies sensation to the back of the tongue and to the pharynx

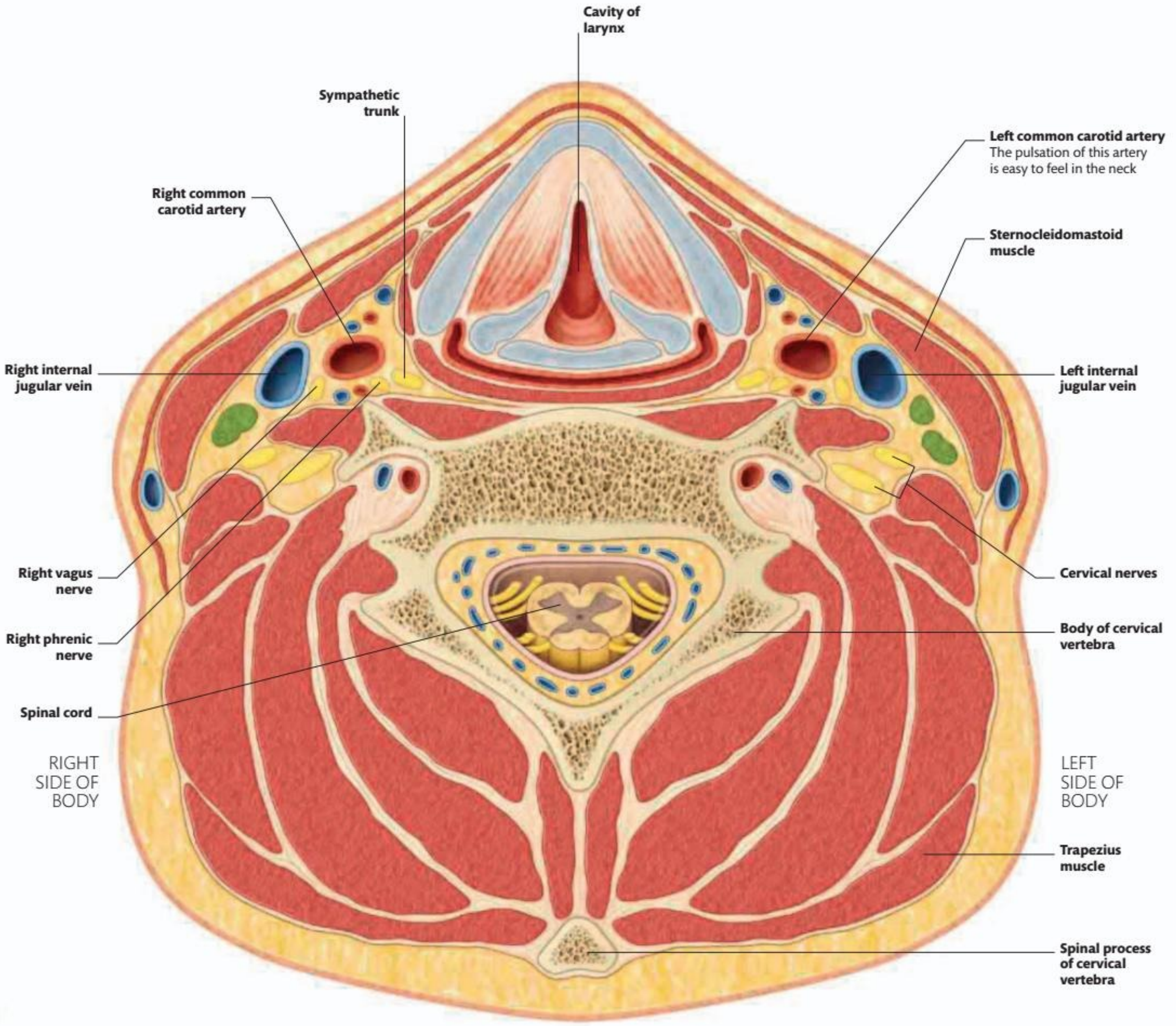
Hypoglossal nerve (CN XII)
Supplies the muscles of the tongue

Vagus nerve (CN X)
Supplies muscles of the pharynx and larynx, and continues down to supply organs in the thorax and abdomen

NERVES OF THE NECK (SIDE)

NECK

The last four cranial nerves all appear in the neck. The glossopharyngeal nerve supplies the parotid gland and the back of the tongue, then runs down to the pharynx. The vagus nerve is sandwiched between the common carotid artery and the internal jugular vein, and it gives branches to the pharynx and larynx before continuing down into the thorax. The accessory nerve supplies the sternocleidomastoid and trapezius muscles in the neck, while the last cranial nerve, the hypoglossal, dips down below the mandible, then curves back up to supply the muscles of the tongue. We can also see spinal nerves in the neck. The upper four cervical nerves supply neck muscles and skin, while the lower four contribute to the brachial plexus and are destined for the arm.



TRANSVERSE SECTION OF THE NECK

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Vagus nerve
The tenth cranial nerve strays a long way beyond the neck to supply structures in the thorax and abdomen as well; its name means wandering or straying

First rib

First intercostal nerve
Anterior branch of T1 (first thoracic) spinal nerve

Phrenic nerve
Comes from the third, fourth, and fifth cervical nerves; supplies the muscle of the diaphragm and the membranes lining either side of it—the pleura on the thoracic side and peritoneum on the abdominal side

ANTERIOR (FRONT)

THORAX

Pairs of spinal nerves emerge via the intervertebral foramina (openings) between the vertebrae. Each nerve splits into an anterior and a posterior branch. The posterior branch supplies the muscles and skin of the back. The anterior branches of the upper 11 thoracic spinal nerves run, one under each rib, as intercostal nerves, supplying the intercostal muscles and overlying skin. The anterior branch of the last thoracic spinal nerve runs under the twelfth rib as the subcostal nerve. In addition to motor and sensory fibers, thoracic spinal nerves contain sympathetic nerve fibers that are linked by tiny connecting branches to the sympathetic chain or trunk (see pp.108–109). This allows sympathetic nerves originating from one level of the spinal cord to travel up and down, and spread out to several body segments.

Sixth rib

Eighth rib

Eighth intercostal nerve
Like each intercostal nerve, this supplies the muscles lying in the same intercostal space, and also supplies sensation to a strip of skin around the thorax

Twelfth rib

Eleventh rib

Subcostal nerve
Anterior branch of T12 nerve, in series with the intercostal nerves; named subcostal as it lies under the last rib

T1 (first thoracic) vertebra

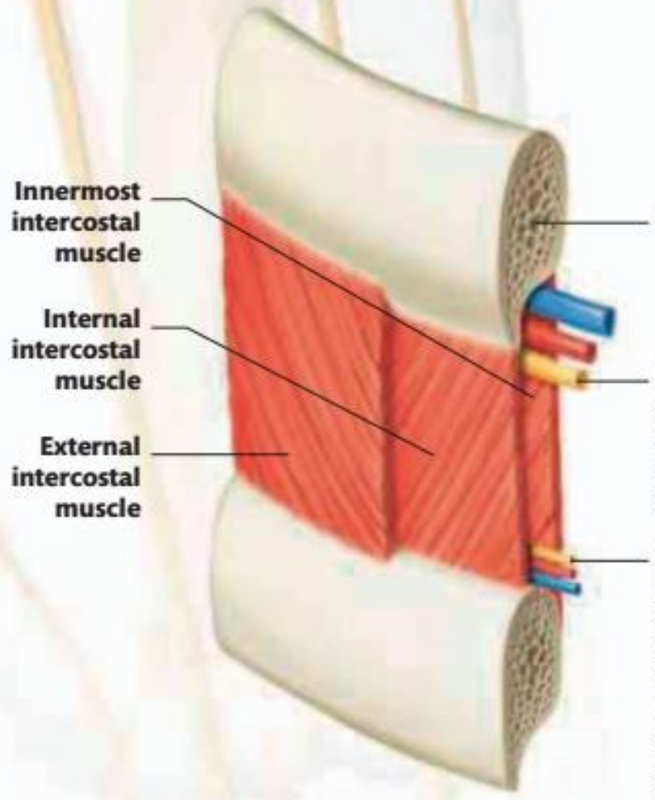
T1 spinal nerve
Emerges from the intervertebral foramen between T1 and T2 vertebrae

Fifth rib

Fifth intercostal nerve
Anterior branch of T5 spinal nerve; lies in the gap between the fifth and sixth ribs

T12 vertebra

Eleventh intercostal nerve
Lying between the eleventh and twelfth ribs, this is the last intercostal nerve



SECTION THROUGH RIBS

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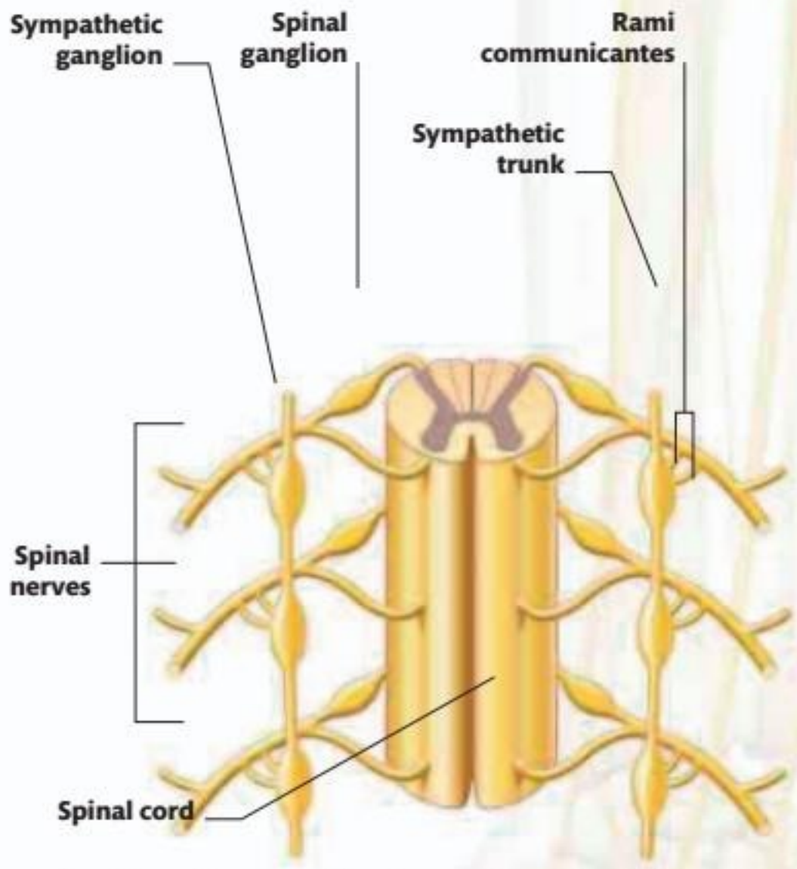
ABDOMEN AND PELVIS

The lower intercostal nerves continue past the lower edges of the ribcage at the front to supply the muscles and skin of the abdominal wall. The lower parts of the abdomen are supplied by the subcostal and iliohypogastric nerves. The abdominal portion of the sympathetic trunk receives nerves from the thoracic and first two lumbar spinal nerves, and sends nerves back to all the spinal nerves. The lumbar spinal nerves emerge from the spine and run into the psoas major muscle at the back of the abdomen. Inside the muscle, the nerves join up and swap fibers to form a network, or plexus. Branches of this lumbar plexus emerge around and through the psoas muscle and make their way into the thigh. Lower down, branches of the sacral plexus supply pelvic organs and enter the buttock. One of these branches, the sciatic nerve, is the largest nerve in the entire body. It supplies the back of the thigh, as well as the rest of the leg and foot.



Section of sympathetic trunk and spinal cord
Branches from the sympathetic trunk innervate the organs of the abdomen and pelvis

Genitofemoral nerve
Splits into two branches: the genital branch supplies some of the scrotum or labium majus, while the femoral branch supplies a small patch of skin at the top of the thigh

Iliohypogastric nerve
Runs around the side of the lower abdomen to supply the lowest parts of the muscles and skin of the abdominal wall

Ilioinguinal nerve
Travels through the layers of the abdominal wall, then down to supply sensation in the front of the scrotum in the male, or the labia majora in the female

Femoral nerve
Supplies the front of the thigh

Sacral plexus
Nerve roots from the fourth and fifth lumbar nerves join the upper four sacral nerves to form this network. Pelvic splanchnic nerves come from the second to fourth sacral nerve roots, and convey parasympathetic nerve fibers to the pelvic organs, via the pelvic plexus on each side

Lateral cutaneous nerve of the thigh
Supplies the skin of the side of the thigh

Obturator nerve
Travels along the inside of the pelvis, then emerges through the obturator foramen to supply the inner thigh

T12 (twelfth thoracic) vertebra

Twelfth rib

Intercostal nerve

Subcostal nerve

Lumbar plexus

Iliac crest

Lumbosacral trunk
Carries nerve fibers from the fourth and fifth lumbar nerves down to join the sacral plexus

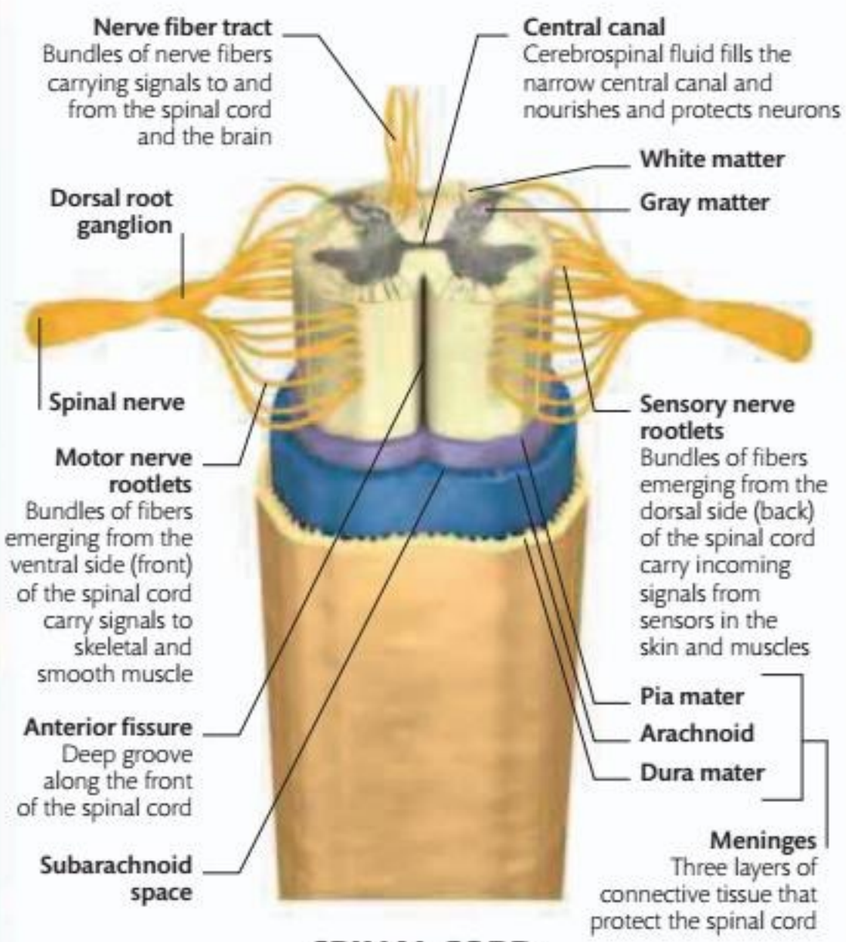
Superior gluteal nerve
Branch of the sacral plexus that supplies muscles and skin in the buttock

Anterior sacral foramen

Sciatic nerve

ANTERIOR (FRONT)

STRUCTURE OF THE SPINAL CORD



SPINAL CORD

The walls of the abdomen and pelvis are supplied by nerves emerging from the spinal cord. Like the brain, the spinal cord contains gray matter (mostly neuron cell bodies) and white matter (axons), and is covered in the same three layers of meninges: dura mater, arachnoid, and pia mater (see p.119).

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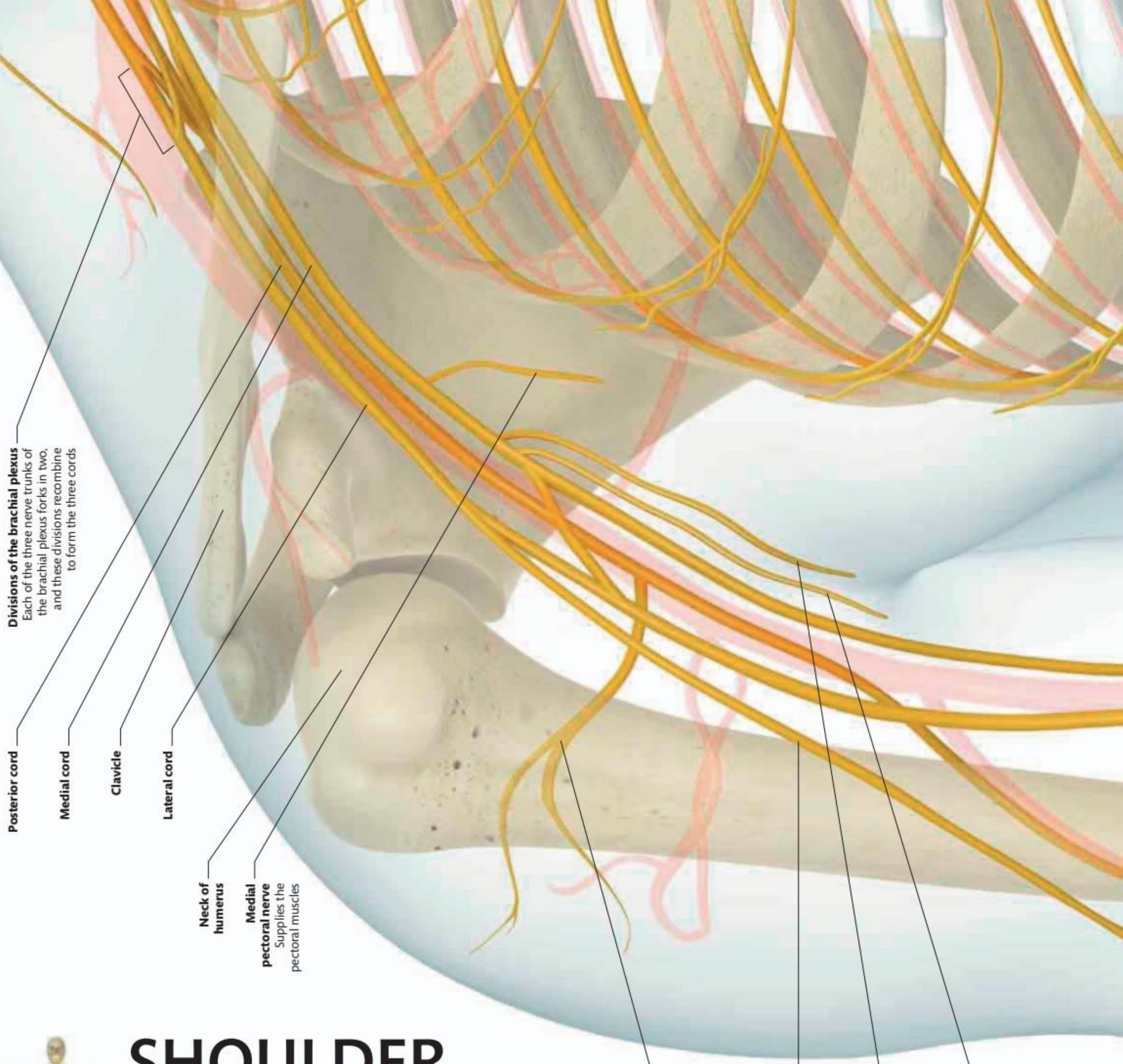
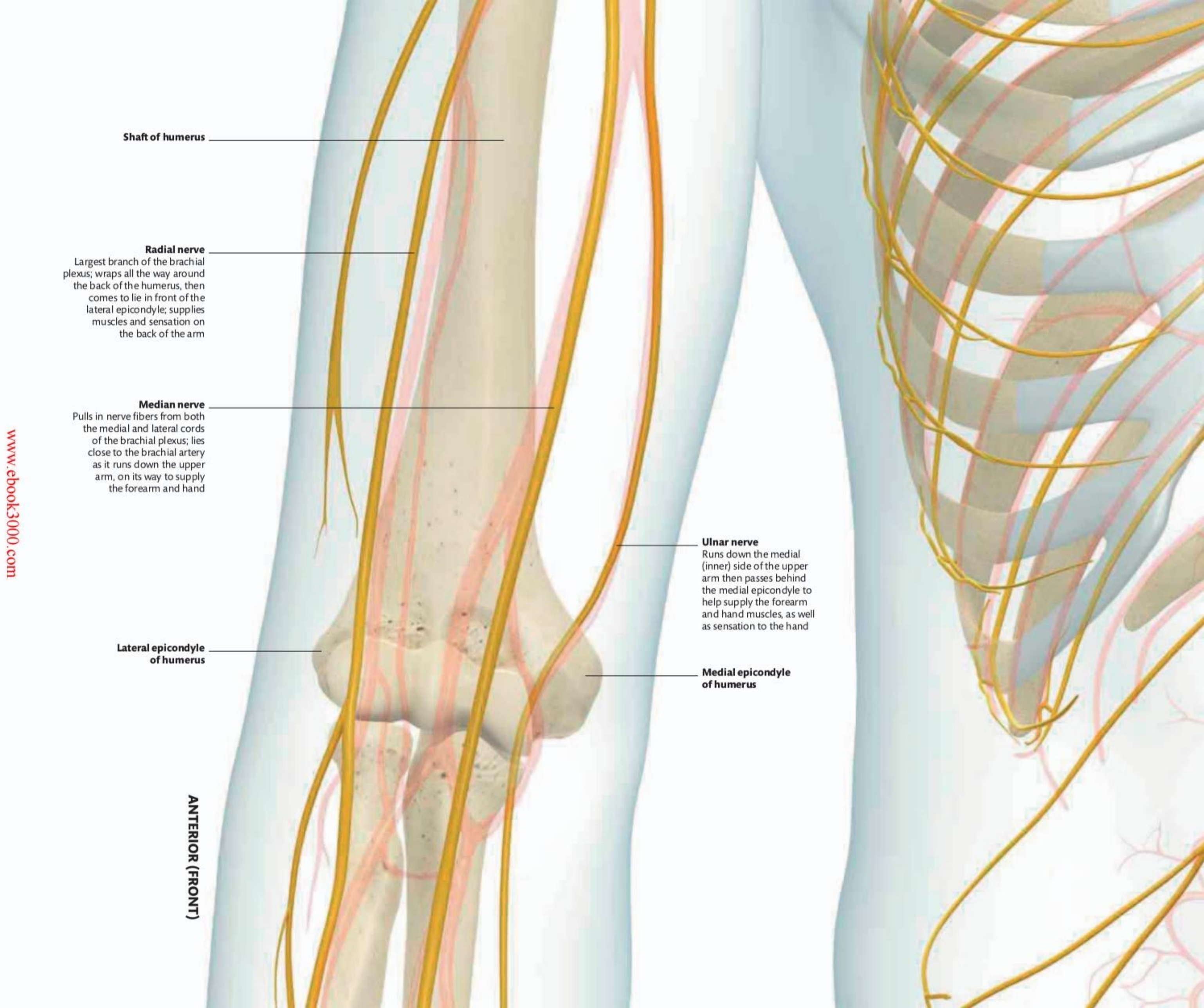


Divisions of the brachial plexus
Each of the three nerve trunks of the brachial plexus forks in two, and these divisions recombine to form the three cords

SHOULDER AND UPPER ARM

The upper limb (shoulder to hand) is supplied by five thick nerve roots that branch from the last four cervical and first thoracic spinal nerves. Emerging between the scalene muscles of the neck, they link up to form a complex skein (network) called the brachial plexus that dives under the clavicle to enter the axilla—the space between the upper arm and the chest. At this point, the plexus comprises three cords lying around the axillary artery. The network's five major nerves—musculocutaneous, median, ulnar, axillary, and radial—provide sensation to the upper limb and supply its muscles. The musculocutaneous nerve supplies the muscles in the front of the arm: the biceps, brachialis, and coracobrachialis.



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SHOULDER AND UPPER ARM

The axillary and radial nerves emerge from the back of the brachial plexus and run behind the humerus. The axillary nerve wraps around the neck of the humerus, just underneath the shoulder joint, and supplies the deltoid muscle. The radial nerve—the largest branch of the brachial plexus—supplies all the extensor muscles in the upper arm and in the forearm. It spirals around the back of the humerus, lying right against the bone, and sends branches to supply the heads of the triceps. The radial nerve then continues in its spiral, running forward to lie just in front of the medial epicondyle of the humerus at the elbow.

Axillary nerve
Wraps around the neck of the humerus, just below the shoulder joint, and is at risk of damage if the shoulder dislocates

Medial cutaneous nerve of the arm

Medial cutaneous nerve of the forearm

Musculocutaneous nerve
After supplying muscles in the front of the arm, this continues as a cutaneous nerve, which will supply sensation to the skin of the lateral (outer) forearm

Lateral cord

Posterior cord

Medial cord

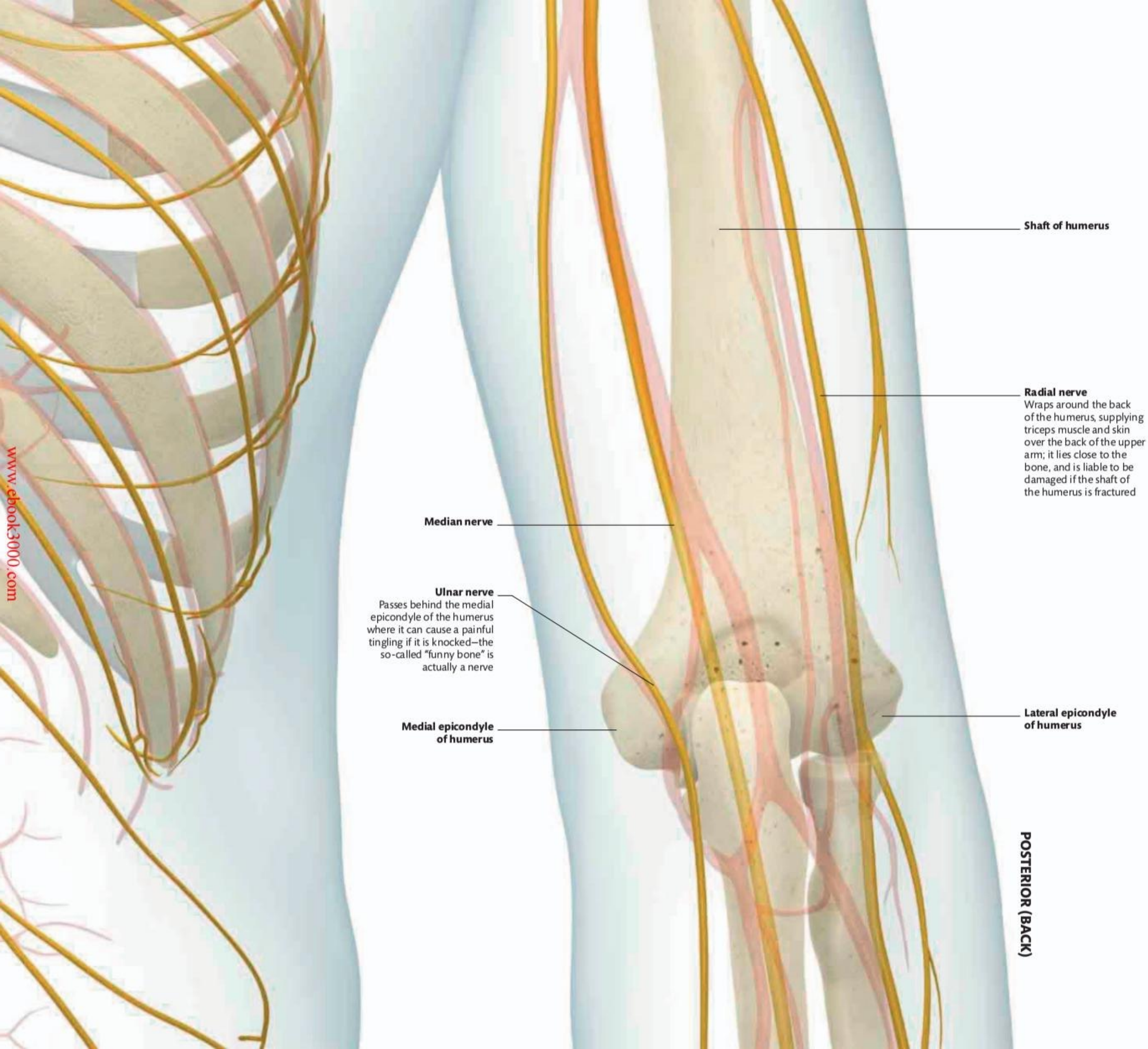
Clavicle

Medial pectoral nerve

Head of humerus

Neck of humerus

Divisions of the brachial plexus



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POSTERIOR (BACK)

Digital branches of the median nerve

Digital branches of the median nerve

Branches of the superficial radial nerve
This nerve branches across the dorsum of the hand, supplying sensation to the back of the hand and fingers; it can become painfully compressed at the wrist—for example, by tight bracelets or handcuffs

Median nerve
Supplies two small muscles in the hand, the small muscles in the ball of the thumb, and sensation to the thumb, index, middle, and half of the ring finger

Radius

Pisiform bone

Communicating branch between median and ulnar palmar digital nerves

Ulnar nerve
Supplies most of the small muscles in the hand

Ulna

ANTERIOR (FRONT)

Radial nerve
Branches at the elbow

Median nerve
Passes through a triangular area on the inside of the elbow known as the cubital fossa

Ulnar nerve
Supplies flexor carpi ulnaris and some of flexor digitorum profundus muscles in the forearm

Superficial radial nerve
Branch of the radial nerve that runs down to the wrist, just tucked underneath brachioradialis muscle on the outer (radial) side of the forearm

Posterior interosseous nerve
Branch of the radial nerve that passes backward around the radius

Median nerve
Supplies most of the flexor muscles in the front of the forearm

Radius

Ulna

Ulnar nerve
Passes into the hand, close to the pisiform bone, where it can get compressed—for example, when using vibrating machinery or when holding a motorbike handlebar

Median nerve
Passes under the flexor retinaculum—through the carpal tunnel—into the wrist; it may become compressed here, producing carpal tunnel syndrome

Pisiform bone

LOWER ARM AND HAND

The front of the forearm is supplied by the musculocutaneous, median, and ulnar nerves. The musculocutaneous nerve supplies sensation to the lateral side of the forearm. The median nerve runs down the middle of the forearm, supplying most of the flexor muscles. It then travels over the wrist and into the hand to supply some of the thumb muscles, as well as sensation to the palm, thumb, and some fingers. The ulnar nerve courses down the inner side of the forearm, where it supplies just two muscles. It continues on to supply most of the small muscles in the hand and provide sensation to the inner side of the ring finger, and also the little finger. On the back of the forearm, the radial nerve and its branches supply all the extensor muscles. Branches of the radial nerve fan out over the back of the hand, where they provide sensation.

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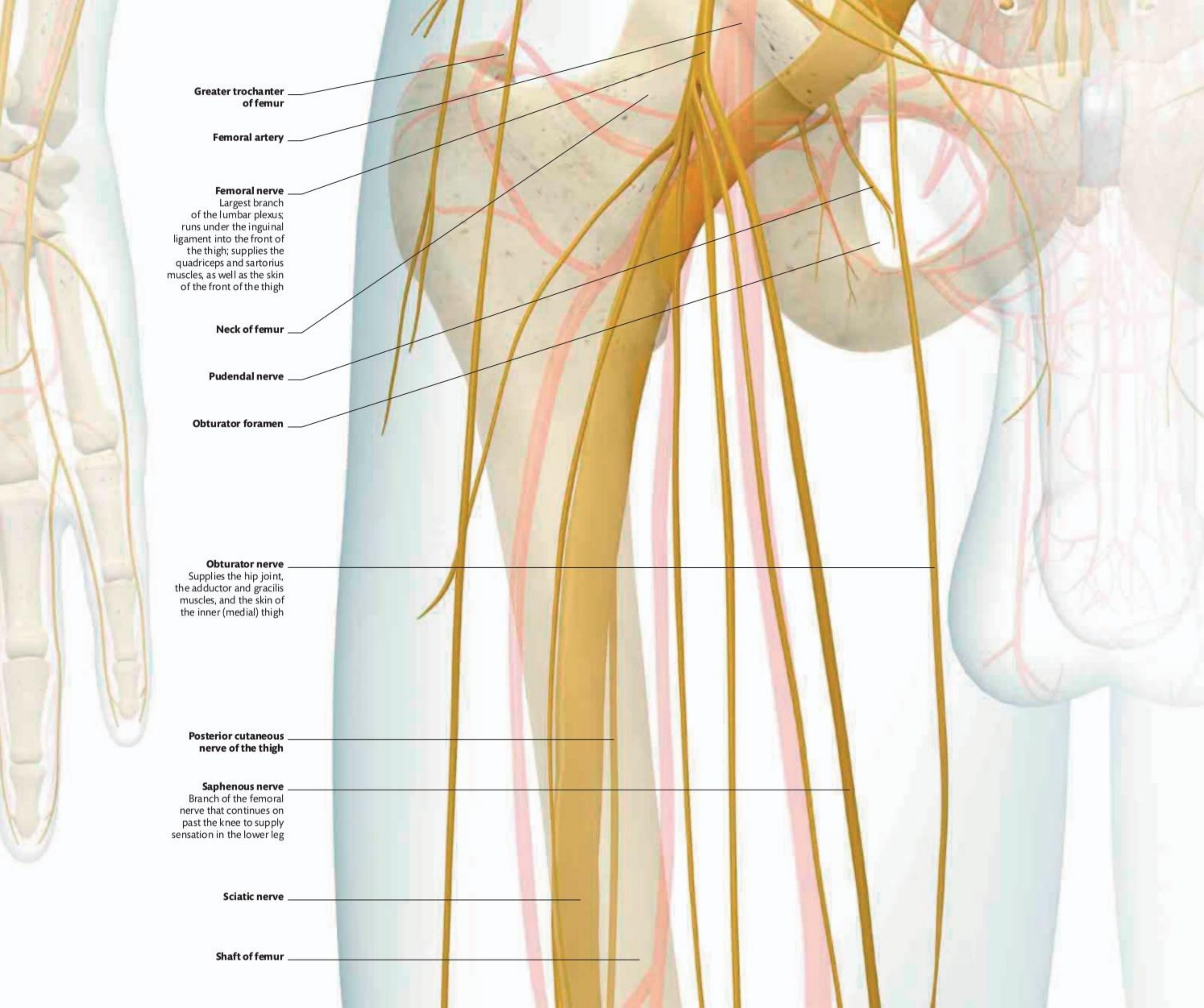
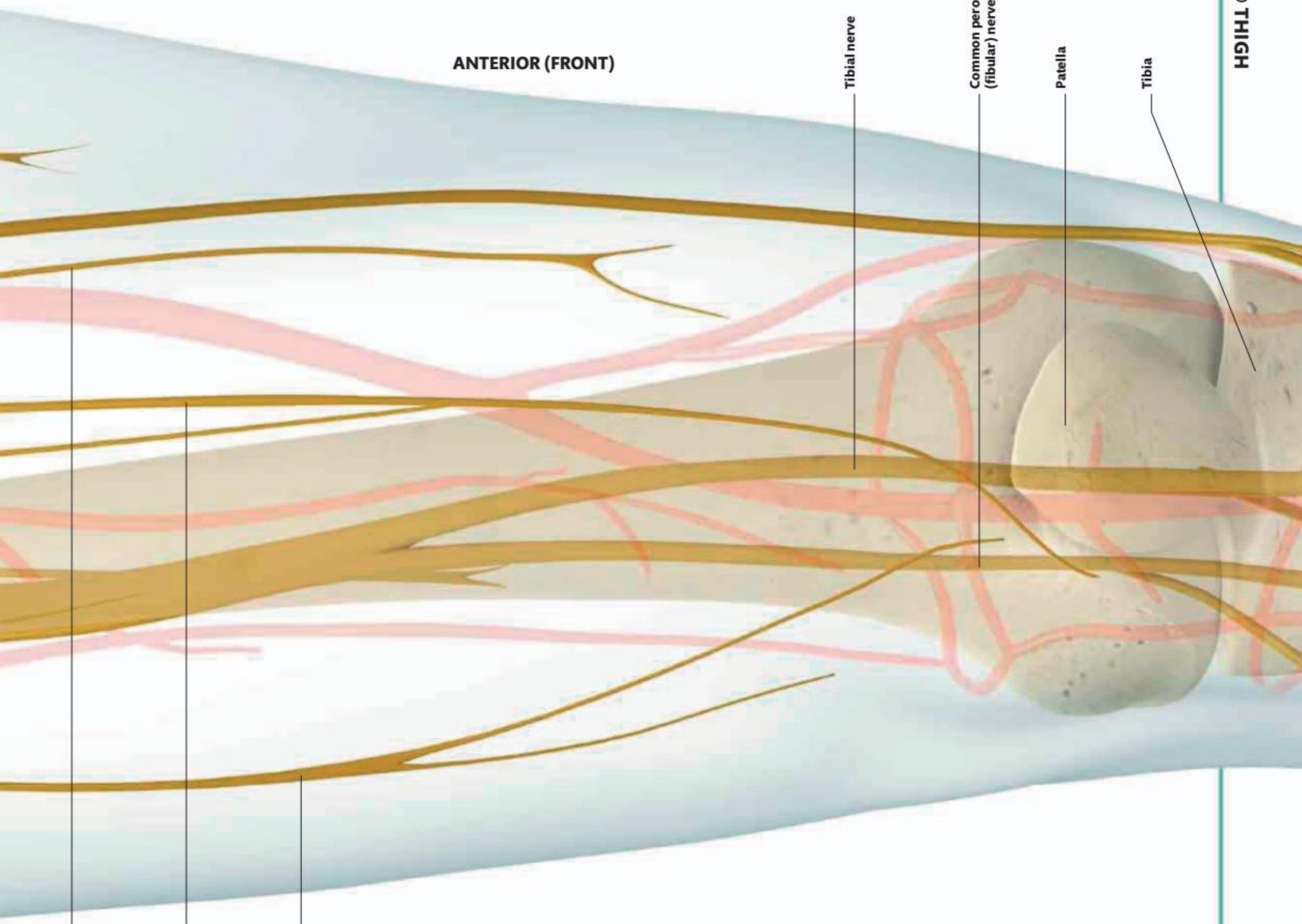

Greater trochanter of femur
Femoral artery
Femoral nerve
Largest branch of the lumbar plexus; runs under the inguinal ligament into the front of the thigh; supplies the quadriceps and sartorius muscles, as well as the skin of the front of the thigh
Neck of femur
Pudendal nerve
Obturator foramen
Obturator nerve
Supplies the hip joint, the adductor and gracilis muscles, and the skin of the inner (medial) thigh
Posterior cutaneous nerve of the thigh
Saphenous nerve
Branch of the femoral nerve that continues on past the knee to supply sensation in the lower leg
Sciatic nerve
Shaft of femur



HIP AND THIGH

The lower limb (hip, thigh, leg, and foot) receives nerves from the lumbar and sacral plexuses. Three main nerves supply the thigh muscles: the femoral, obturator, and sciatic nerves (the last in the back). The femoral nerve runs over the pubic bone to supply the quadriceps and sartorius muscles in the front. The saphenous nerve, a slender branch of the femoral, continues past the knee and supplies skin on the inside of the lower leg and the inner side of the foot. The obturator nerve passes through the obturator foramen in the pelvic bone to supply the adductor muscles of the inner thigh and provide sensation to the skin there. Some smaller nerves just supply skin, such as the femoral cutaneous nerves.

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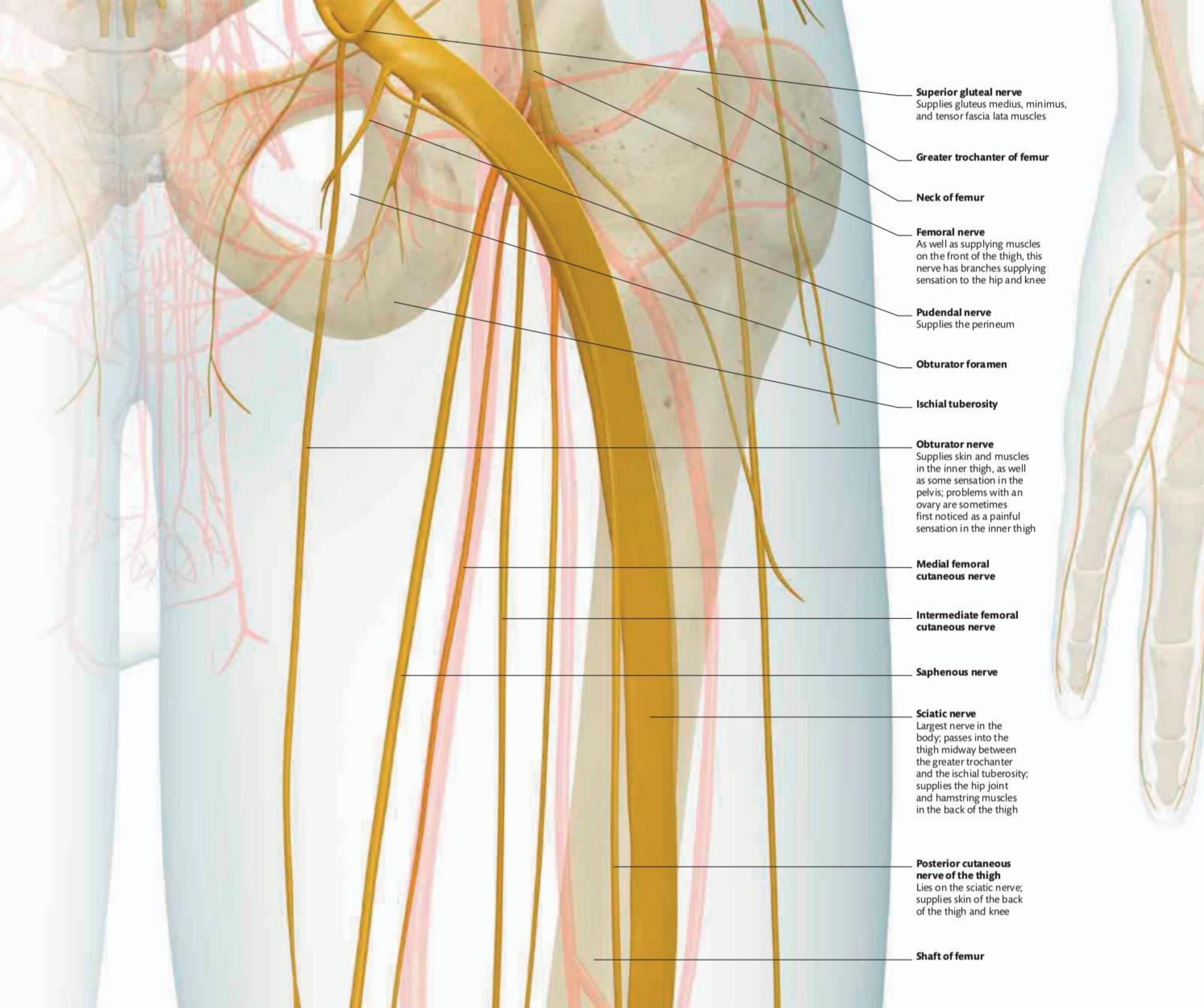
Superior gluteal nerve
Supplies gluteus medius, minimus, and tensor fascia lata muscles
Greater trochanter of femur
Neck of femur
Femoral nerve
As well as supplying muscles on the front of the thigh, this nerve has branches supplying sensation to the hip and knee
Pudendal nerve
Supplies the perineum
Obturator foramen
Ischial tuberosity
Obturator nerve
Supplies skin and muscles in the inner thigh, as well as some sensation in the pelvis; problems with an ovary are sometimes first noticed as a painful sensation in the inner thigh
Medial femoral cutaneous nerve
Intermediate femoral cutaneous nerve
Saphenous nerve
Sciatic nerve
Largest nerve in the body; passes into the thigh midway between the greater trochanter and the ischial tuberosity; supplies the hip joint and hamstring muscles in the back of the thigh
Posterior cutaneous nerve of the thigh
Lies on the sciatic nerve; supplies skin of the back of the thigh and knee
Shaft of femur

HIP AND THIGH

Gluteal nerves from the sacral plexus emerge via the greater sciatic foramen, at the back of the pelvis, to supply the muscles and skin of the buttock. The sciatic nerve also emerges through the greater sciatic foramen into the buttock. The gluteus maximus is a good site for injections into a muscle, but these should always be given in the upper, outer part of the buttock to make sure the needle is well away from the sciatic nerve. The sciatic nerve runs down the back of the thigh, supplying the hamstrings. In most people, the sciatic nerve runs halfway down the thigh then splits into two branches, the tibial and common peroneal nerves. These continue into the popliteal fossa (back of the knee) and on into the lower leg.

Lateral femoral cutaneous nerve
May become compressed at the inguinal ligament, causing a painful tingling in the thigh, called meralgia paresthetica

Tibial nerve
One of the main branches of the sciatic nerve, the tibial nerve passes straight down through the popliteal fossa at the back of the knee

Common peroneal (fibular) nerve
The other main branch from the sciatic nerve, the common peroneal nerve diverges from the tibial nerve, lying on the lateral (outer) side of the popliteal fossa

Popliteal surface of the femur

Tibia

POSTERIOR (BACK)

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ANTERIOR (FRONT)

POSTERIOR (BACK)

Saphenous nerve
This cutaneous nerve runs with the great saphenous vein down the inner (medial) side of the lower leg

Tibial nerve

Common peroneal (fibular) nerve
This nerve hugs the edge of biceps femoris muscle, moving to the side and past the knee, where it wraps around the head of the fibula, then divides to form the deep and superficial peroneal nerves

Head of fibula

Sural nerve

Lateral sural cutaneous nerve
(shown cut)

Deep peroneal (fibular) nerve
Lies on the front of the interosseous membrane between the tibia and fibula

Tibial nerve
Passes under the soleus muscle and down the calf, supplying the deep and superficial muscles there

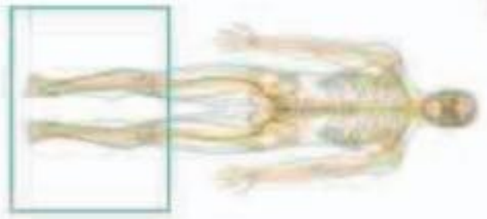
Saphenous nerve

Common peroneal (fibular) nerve
Lies just under the skin and next to bone here; can be damaged when a car hits a pedestrian, since the bumper may be level with the nerve at the head of the fibula

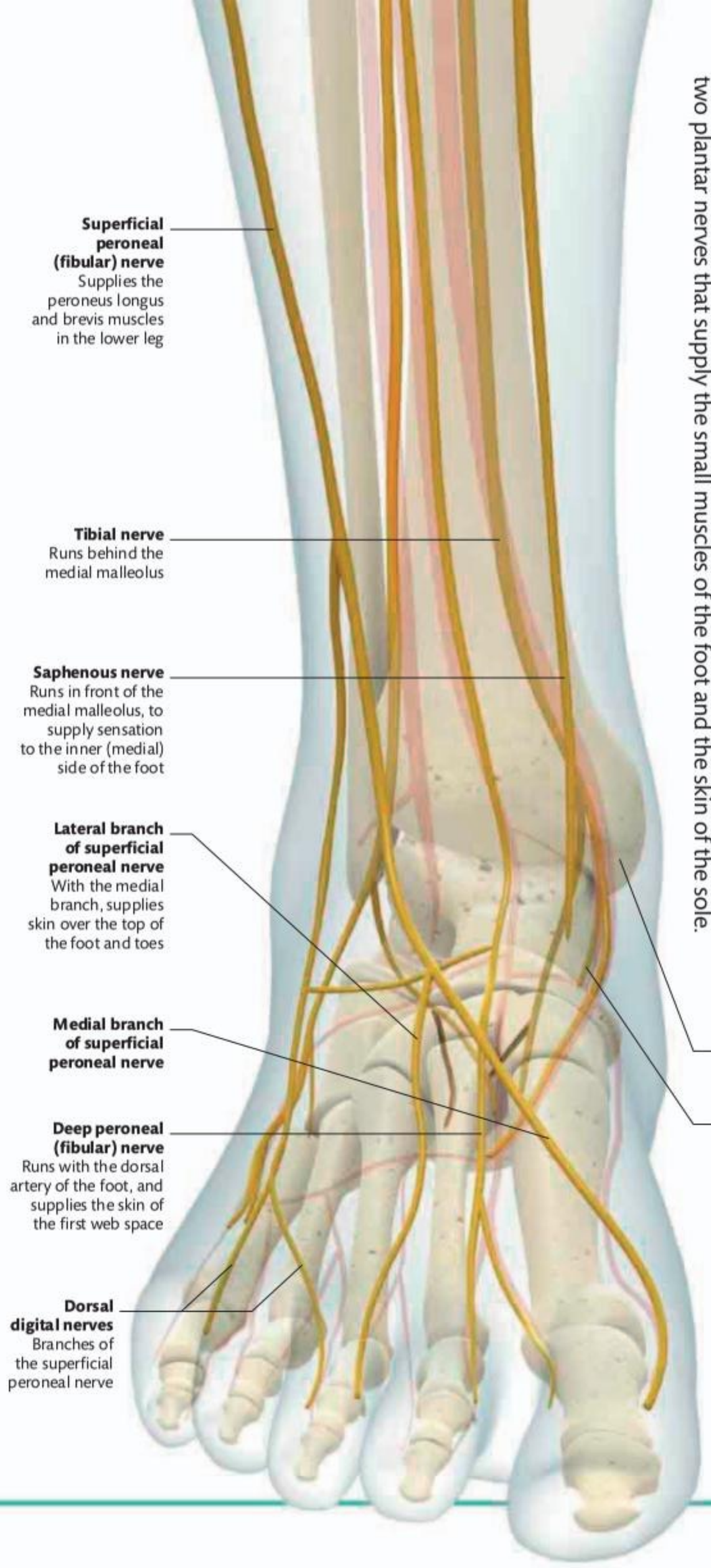
Head of fibula

Sural nerve
Cutaneous branch of the tibial nerve that supplies sensation to the outer side of the calf, foot, and little toe

LOWER LEG AND FOOT



The common peroneal nerve runs past the knee and wraps around the neck of the fibula. Then it splits into the deep and superficial peroneal nerves. The deep peroneal nerve supplies the extensor muscles of the shin, then fans out to provide sensation to the skin at the back of the foot. The superficial peroneal nerve stays on the side of the leg and supplies the peroneal muscles. The tibial nerve runs through the popliteal fossa (back of the knee), under the soleus muscle, and between the deep and superficial calf muscles, which it supplies. It continues behind the medial malleolus and under the foot, then splits into two plantar nerves that supply the small muscles of the foot and the skin of the sole.



Superficial peroneal (fibular) nerve
Supplies the peroneus longus and brevis muscles in the lower leg

Tibial nerve
Runs behind the medial malleolus

Saphenous nerve
Runs in front of the medial malleolus, to supply sensation to the inner (medial) side of the foot

Lateral branch of superficial peroneal nerve
With the medial branch, supplies skin over the top of the foot and toes

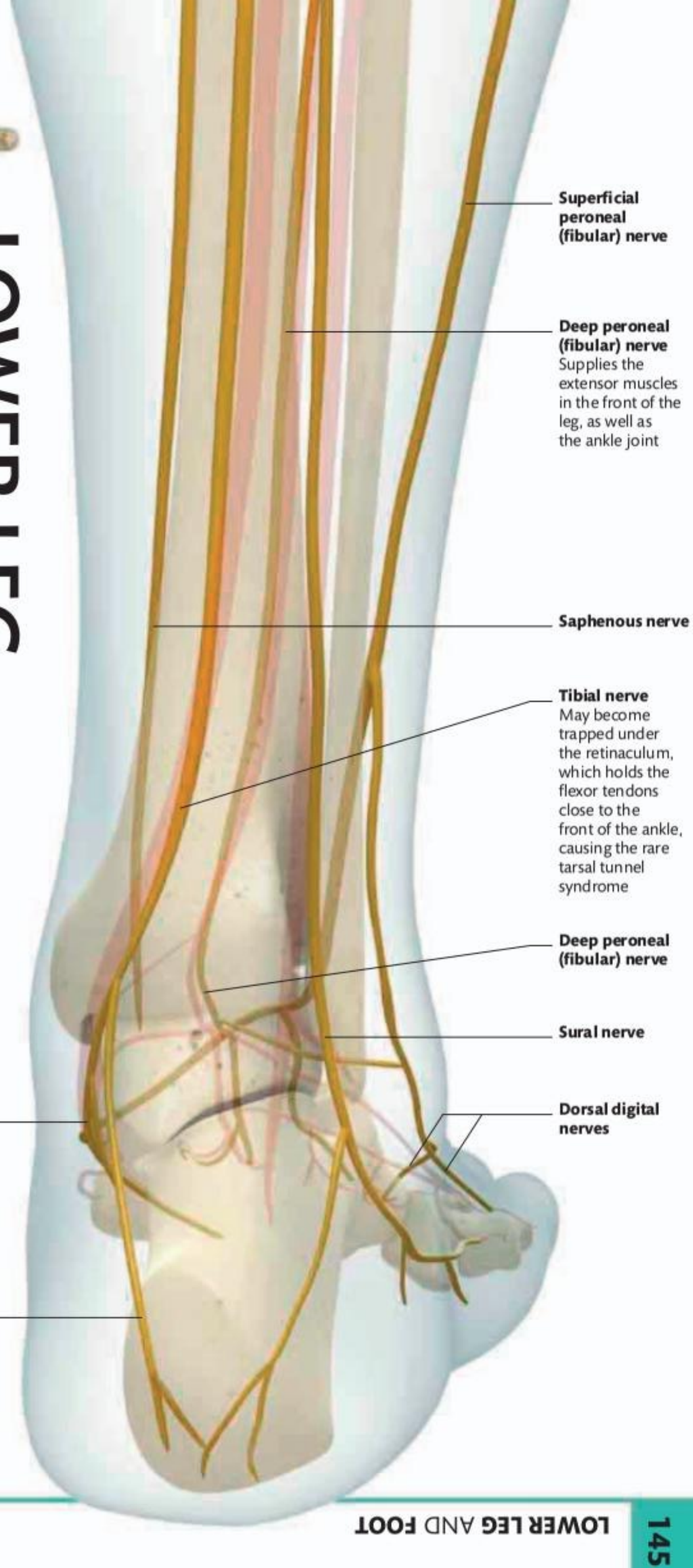
Medial branch of superficial peroneal nerve

Deep peroneal (fibular) nerve
Runs with the dorsal artery of the foot, and supplies the skin of the first web space

Dorsal digital nerves
Branches of the superficial peroneal nerve

Medial malleolus

Lateral plantar nerve
With the medial plantar nerve, supplies the muscles and skin of the sole and toes



Superficial peroneal (fibular) nerve

Deep peroneal (fibular) nerve
Supplies the extensor muscles in the front of the leg, as well as the ankle joint

Saphenous nerve

Tibial nerve
May become trapped under the retinaculum, which holds the flexor tendons close to the front of the ankle, causing the rare tarsal tunnel syndrome

Deep peroneal (fibular) nerve

Sural nerve

Dorsal digital nerves

Medial plantar nerve
One of the terminal branches of the tibial nerve, supplying the sole and toes

Calcaneal branch of tibial nerve
Supplies the heel and inner (medial) sole

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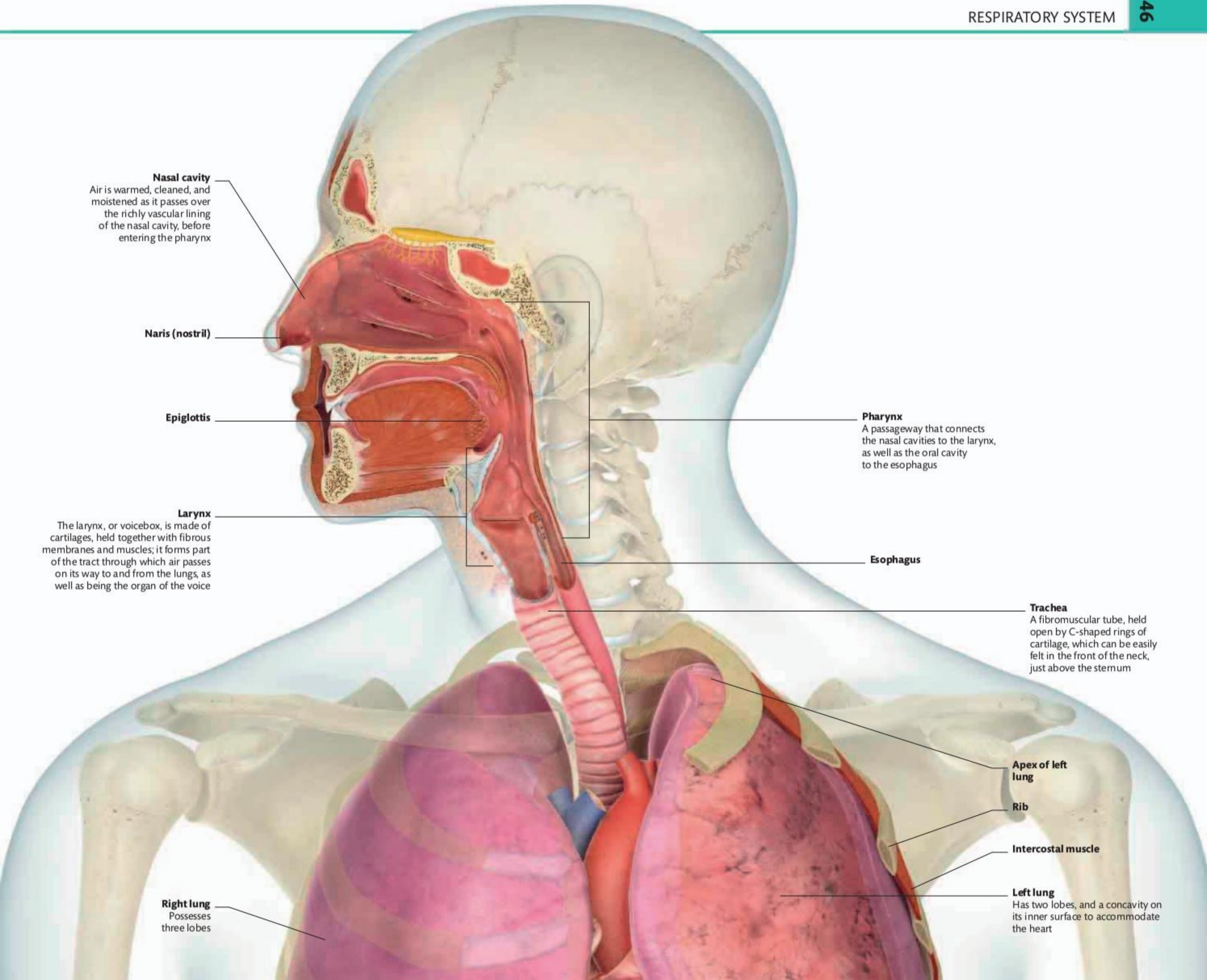
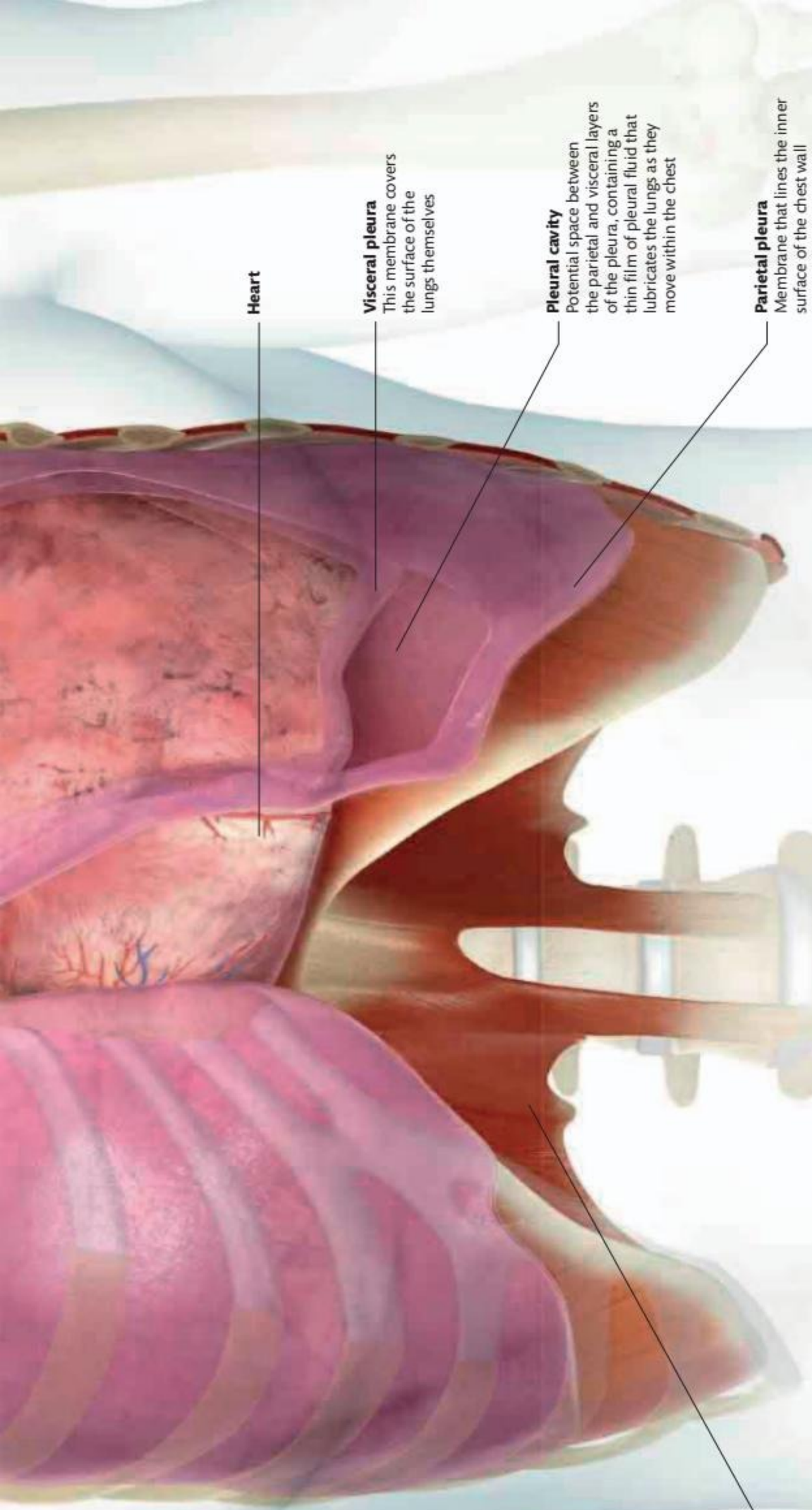

Nasal cavity
Air is warmed, cleaned, and moistened as it passes over the richly vascular lining of the nasal cavity, before entering the pharynx
Naris (nostril)
Epiglottis
Larynx
The larynx, or voicebox, is made of cartilages, held together with fibrous membranes and muscles; it forms part of the tract through which air passes on its way to and from the lungs, as well as being the organ of the voice
Pharynx
A passageway that connects the nasal cavities to the larynx, as well as the oral cavity to the esophagus
Esophagus
Trachea
A fibromuscular tube, held open by C-shaped rings of cartilage, which can be easily felt in the front of the neck, just above the sternum
Apex of left lung
Rib
Intercostal muscle
Left lung
Has two lobes, and a concavity on its inner surface to accommodate the heart
Right lung
Possesses three lobes

RESPIRATORY SYSTEM **OVERVIEW**

Every cell in the human body needs to get oxygen, and to get rid of carbon dioxide. These gases are transported around the body in the blood, but the actual transfer of gases between the air and the blood occurs in the lungs. The lungs have extremely thin membranes that allow the gases to pass across easily. But air also needs to be regularly drawn in and out of the lungs, to expel the building carbon dioxide and to bring in fresh oxygen, and this is brought about by respiration—commonly called breathing. The respiratory system includes the airways on the way to the lungs: the nasal cavities, parts of the pharynx, the larynx, the trachea, and the bronchi (see p.149).



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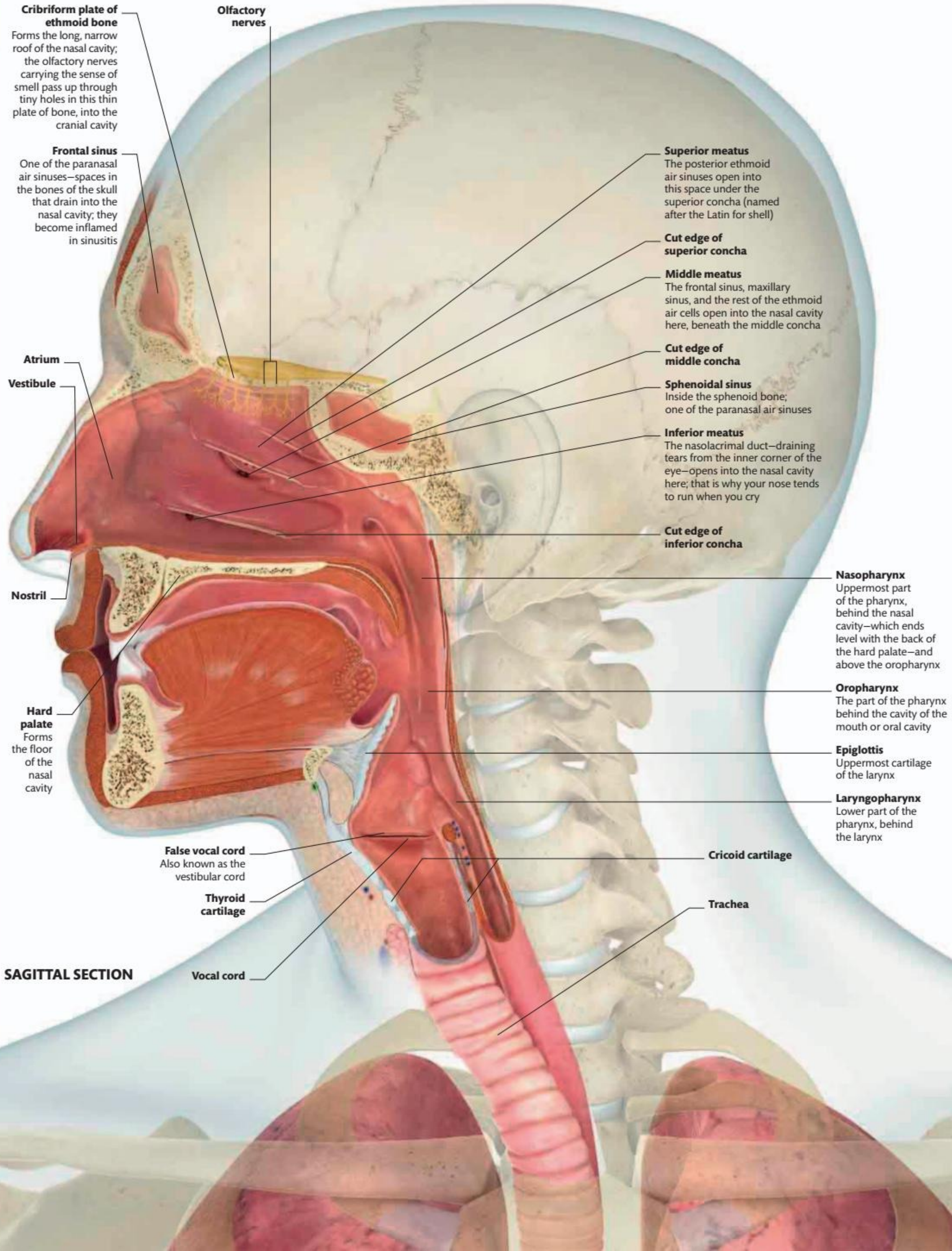
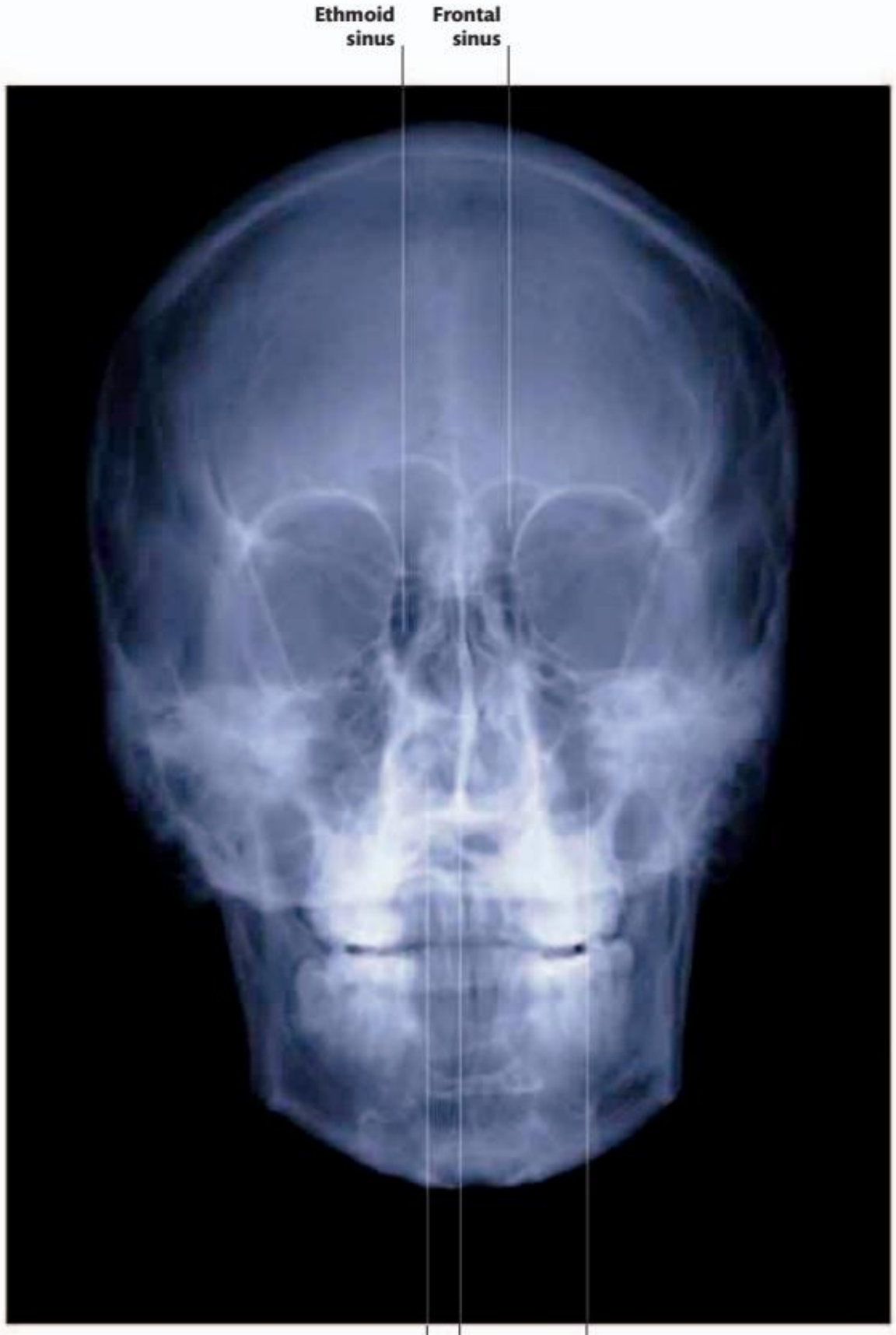
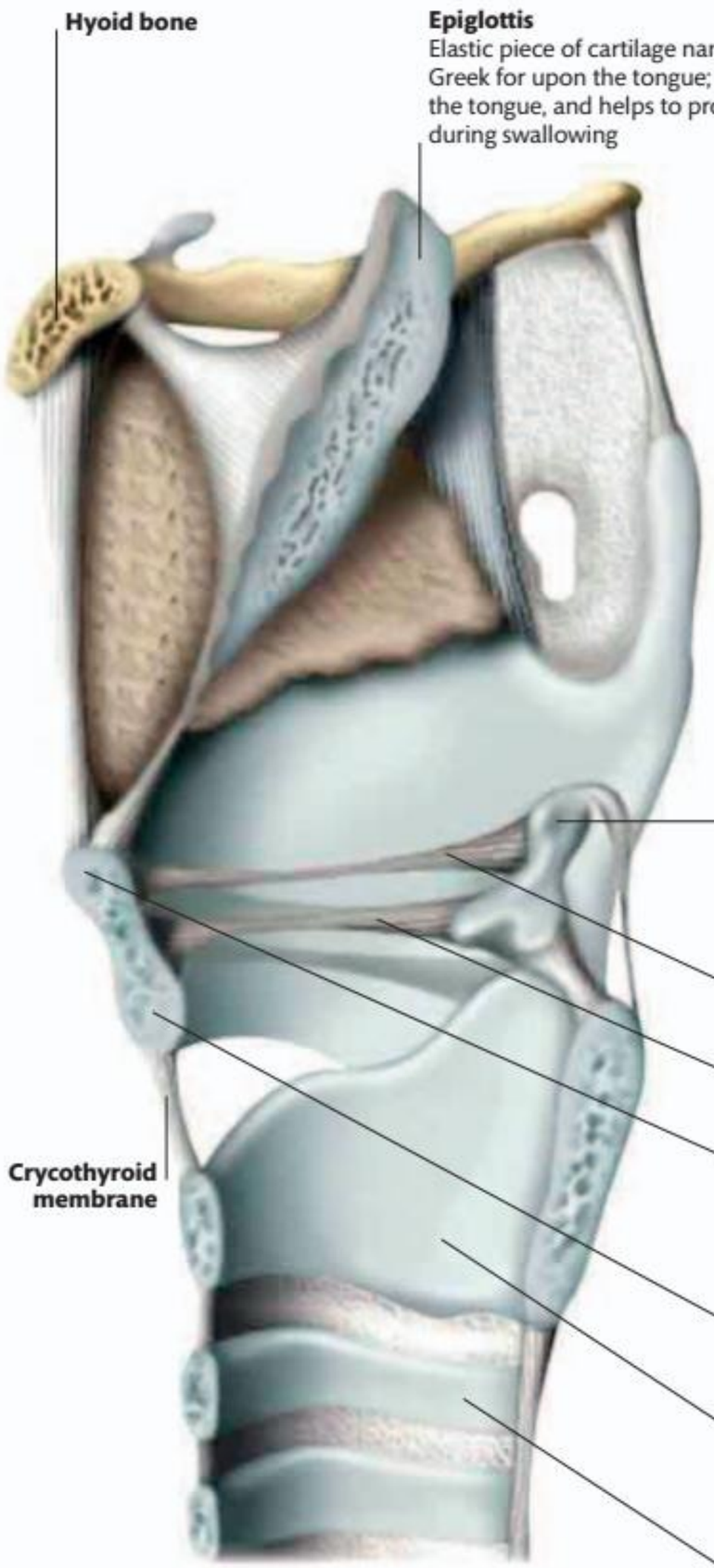

Cribriform plate of ethmoid bone
Forms the long, narrow roof of the nasal cavity; the olfactory nerves carrying the sense of smell pass up through tiny holes in this thin plate of bone, into the cranial cavity
Olfactory nerves
Frontal sinus
One of the paranasal air sinuses—spaces in the bones of the skull that drain into the nasal cavity; they become inflamed in sinusitis
Superior meatus
The posterior ethmoid air sinuses open into this space under the superior concha (named after the Latin for shell)
Cut edge of superior concha
Middle meatus
The frontal sinus, maxillary sinus, and the rest of the ethmoid air cells open into the nasal cavity here, beneath the middle concha
Cut edge of middle concha
Sphenoidal sinus
Inside the sphenoid bone; one of the paranasal air sinuses
Atrium
Vestibule
Inferior meatus
The nasolacrimal duct—draining tears from the inner corner of the eye—opens into the nasal cavity here; that is why your nose tends to run when you cry
Cut edge of inferior concha
Nostril
Nasopharynx
Uppermost part of the pharynx, behind the nasal cavity—which ends level with the back of the hard palate—and above the oropharynx
Hard palate
Forms the floor of the nasal cavity
Oropharynx
The part of the pharynx behind the cavity of the mouth or oral cavity
Epiglottis
Uppermost cartilage of the larynx
Laryngopharynx
Lower part of the pharynx, behind the larynx
False vocal cord
Also known as the vestibular cord
Cricoid cartilage
Thyroid cartilage
Trachea
Vocal cord
SAGITTAL SECTION

HEAD AND NECK

When we take a breath, air is pulled in through our nostrils, into the nasal cavities. Here the air is cleaned, warmed, and moistened before its onward journey. The nasal cavities are divided by the thin partition of the nasal septum, which is composed of plates of cartilage and bone. The lateral walls of the nasal cavity are more elaborate, with bony curls (conchae) that increase the surface area over which the air flows. The nasal cavity is lined with mucosa, which produces mucus. This often undervalued substance does an important job of trapping particles and moistening the air. The nasal sinuses, also lined with mucosa, open via tiny orifices into the nasal cavity. Below and in front of the pharynx is the larynx—the organ of speech. The way that air passes through this can be modulated to produce sound.



X-RAY OF HEAD SHOWING SINUSES



LARYNX

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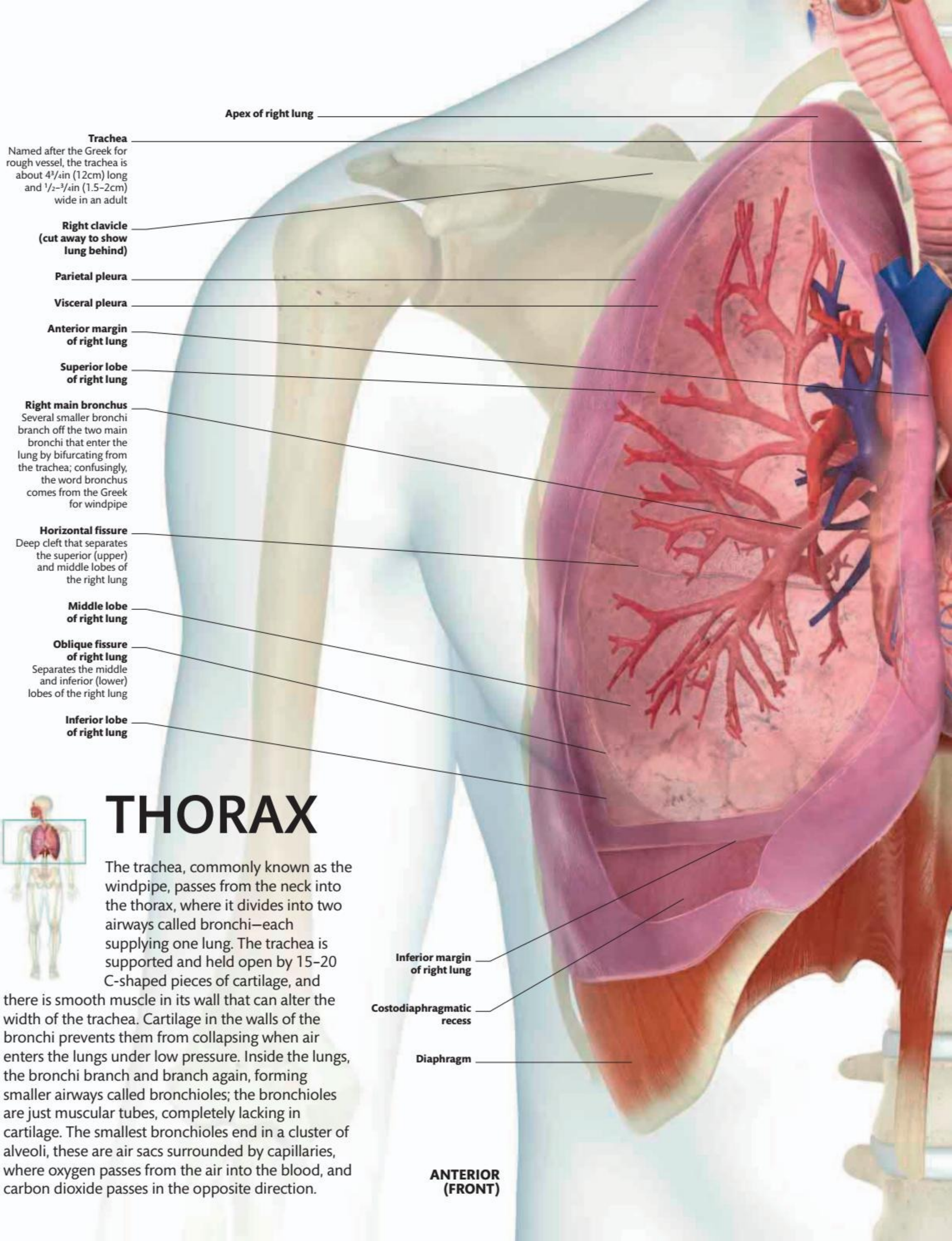


THORAX

The trachea, commonly known as the windpipe, passes from the neck into the thorax, where it divides into two airways called bronchi—each supplying one lung. The trachea is supported and held open by 15–20 C-shaped pieces of cartilage, and there is smooth muscle in its wall that can alter the width of the trachea. Cartilage in the walls of the bronchi prevents them from collapsing when air enters the lungs under low pressure. Inside the lungs, the bronchi branch and branch again, forming smaller airways called bronchioles; the bronchioles are just muscular tubes, completely lacking in cartilage. The smallest bronchioles end in a cluster of alveoli, these are air sacs surrounded by capillaries, where oxygen passes from the air into the blood, and carbon dioxide passes in the opposite direction.

Apex of left lung
The apex, or topmost point, of each lung projects some ³/₄in (2cm) above the clavicle

Left clavicle (cut away to show lung behind)

Bronchus of left lung
Bronchi are lined with epithelium, which produces mucus to trap particles, and carpeted with tiny hairlike projections called cilia that waft mucus up and out of the lungs

Superior lobe of left lung

Anterior margin of left lung

Cardiac notch of left lung
Anterior edge of the left lung that curves inward slightly to accommodate the heart

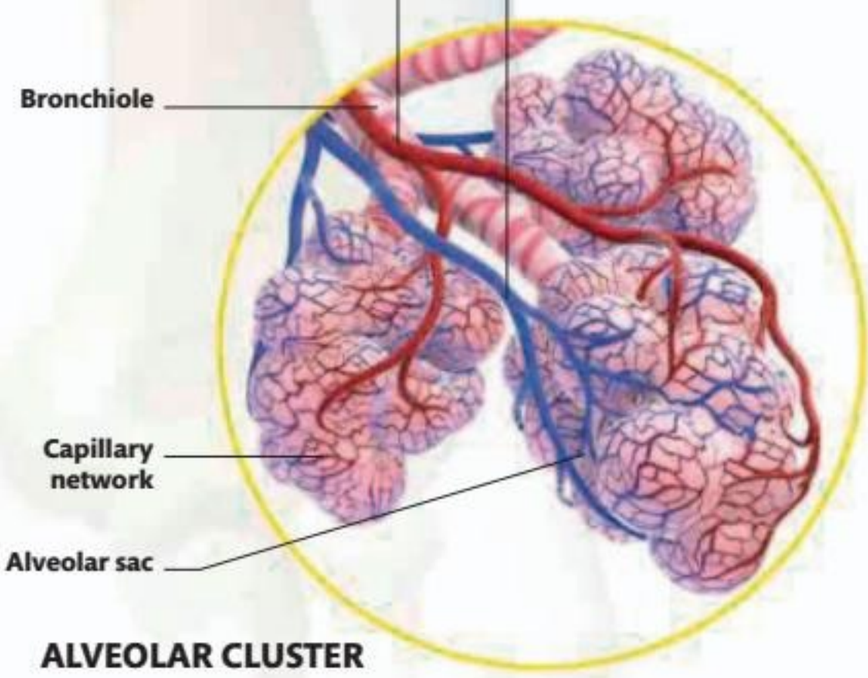
Oblique fissure of left lung
Divides the superior and inferior lobes of the left lung

Bronchiole

Inferior lobe of left lung

Inferior margin of left lung

Lingula
Slight projection of the front edge of the left lung; name originates from the Latin for little tongue



ALVEOLAR CLUSTER

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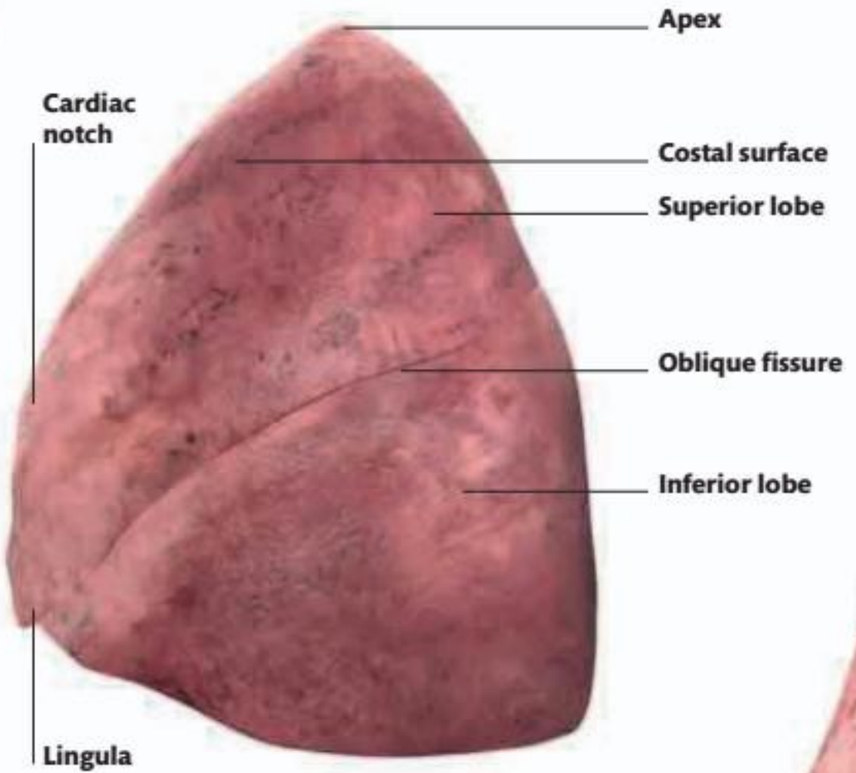
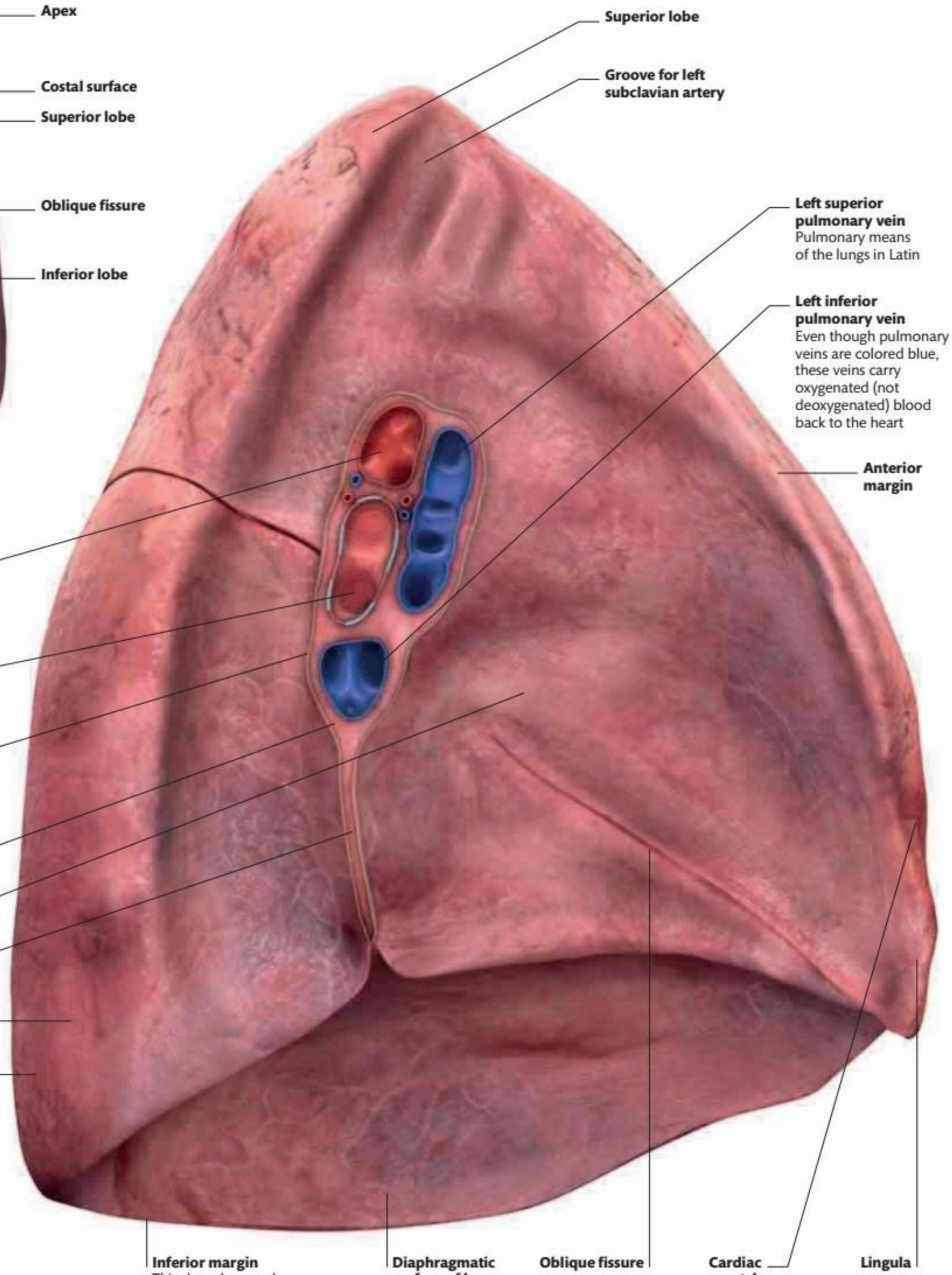
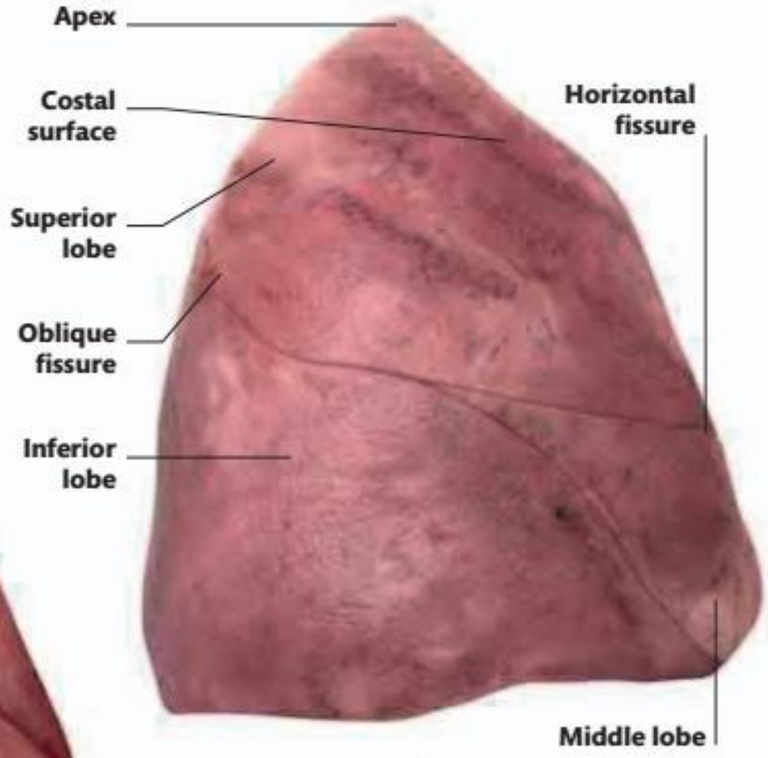


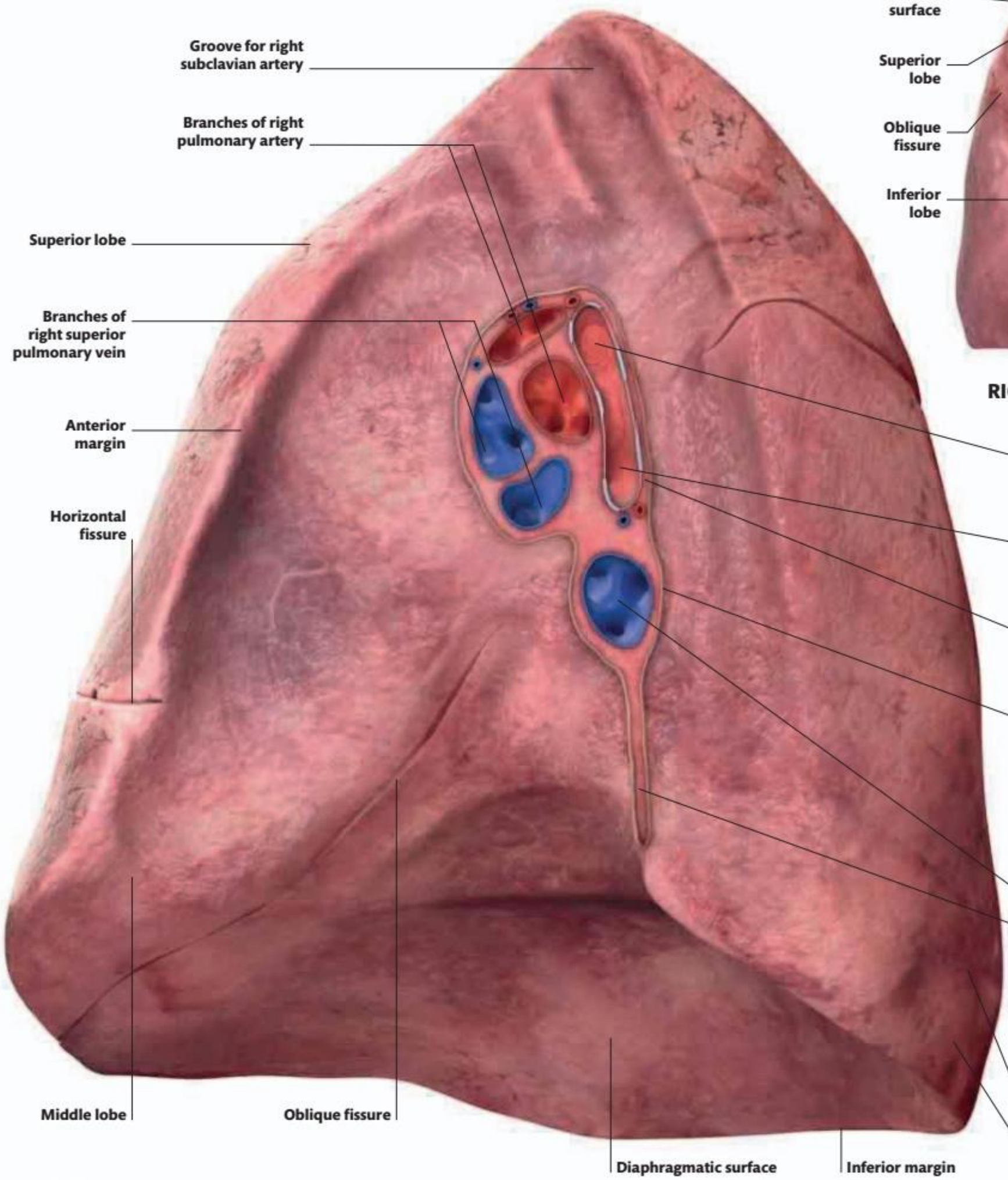
LEFT LUNG (LATERAL VIEW)



LEFT LUNG (MEDIAL VIEW)



RIGHT LUNG (LATERAL VIEW)



Superior lobar bronchus
The structure of the wall of the bronchus, containing rings of cartilage, can be seen in cross section here

Right main bronchus
Having already given off the superior lobar bronchus, this will branch to form the middle and inferior lobar bronchi

Hilum
Depression where the bronchi and major pulmonary vessels enter and leave the lung

Pleura
Around the hilum, the visceral pleura doubles back on itself to form the parietal pleura, which continues on to the inner surface of the ribcage and the upper surface of the diaphragm; the visceral and parietal pleura thus form a continuous, closed envelope around the lung

Right inferior pulmonary vein

Pulmonary ligament
The line where the visceral pleura doubles back on itself to become the parietal pleura hangs down below the hilum, forming this "ligament", which allows the pulmonary veins to expand freely

Costal surface

Inferior lobe

RIGHT LUNG (MEDIAL VIEW)

LUNGS

Each lung fits snugly inside its half of the thoracic cavity. The surface of each lung is covered with a thin pleural membrane (visceral pleura), and the inside of the chest wall is also lined with pleura (parietal pleura). Between the two pleural layers lies a thin film of lubricating fluid that allows the lungs to slide against the chest wall during breathing movements, but it also creates a fluid seal, effectively sticking the lungs to the ribs and the diaphragm. Because of this seal, when you inhale, the lungs are pulled outward in all directions, and air rushes into them. The bronchi and blood vessels enter each lung at the hilum on its inner or medial surface. Although the two lungs may appear to be similar at first glance, there is some asymmetry. The left lung is concave to fit around the heart and has only two lobes, whereas the right lung has three lobes, marked out by two deep fissures.

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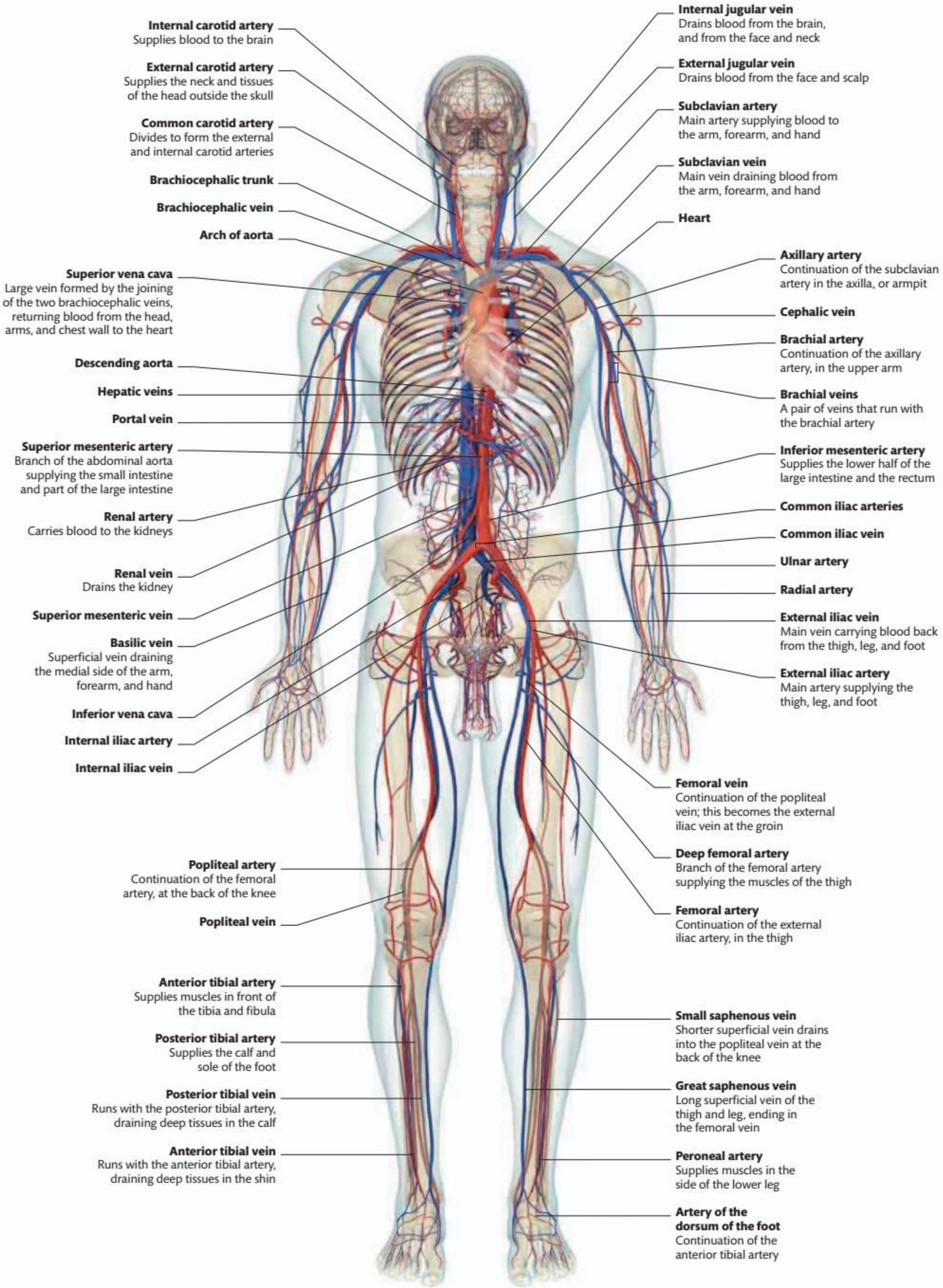
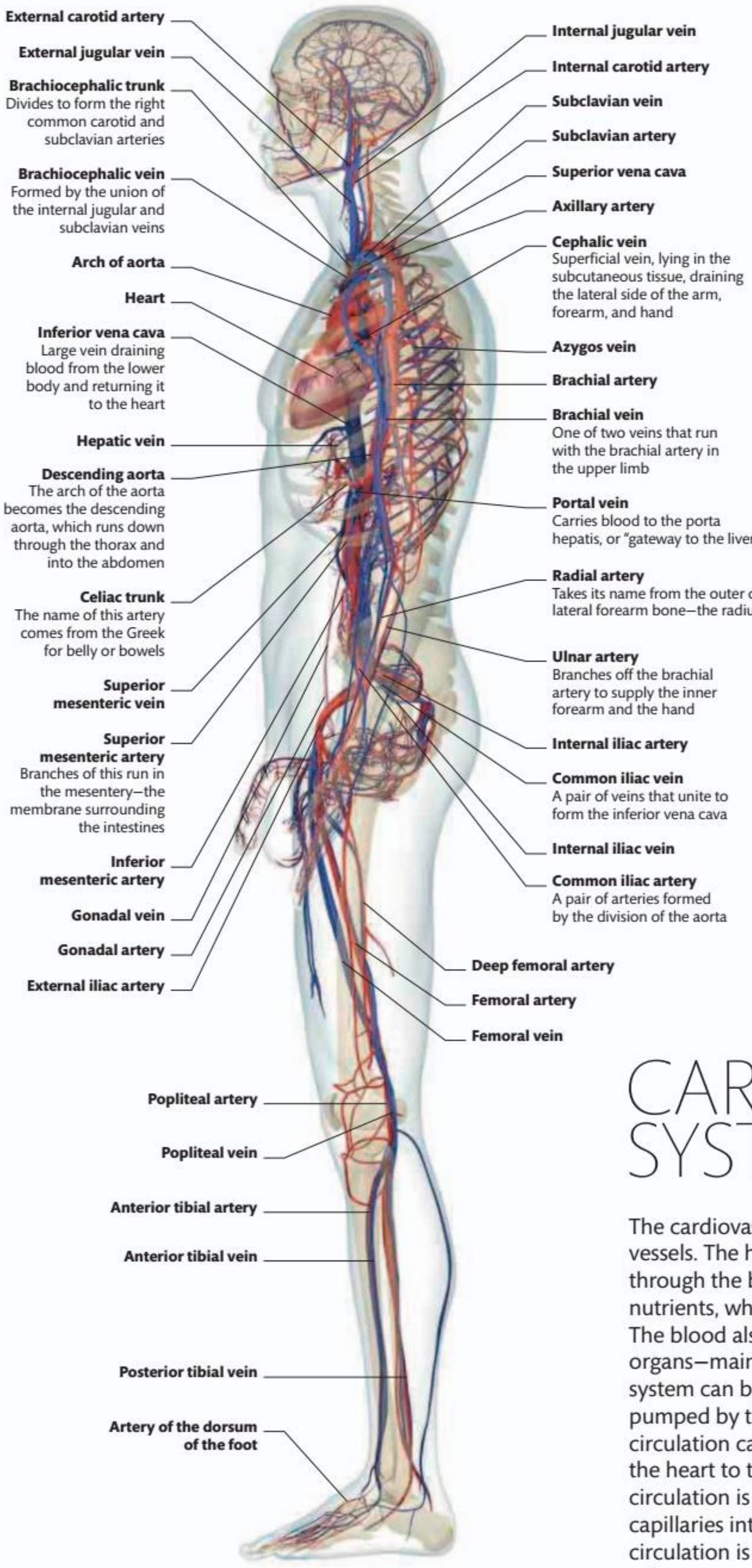


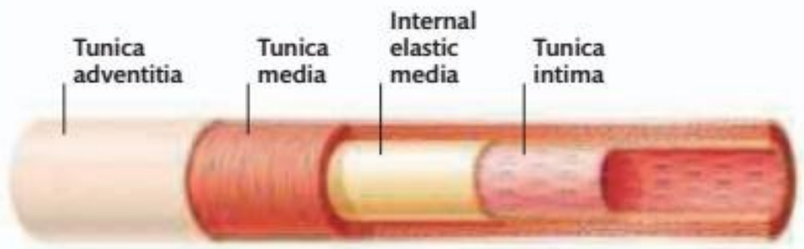
ANTERIOR (FRONT)



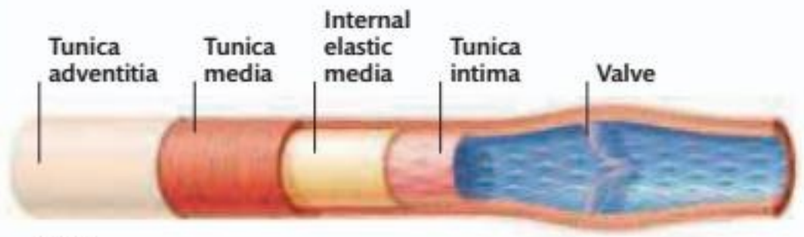
SIDE

BLOOD VESSELS

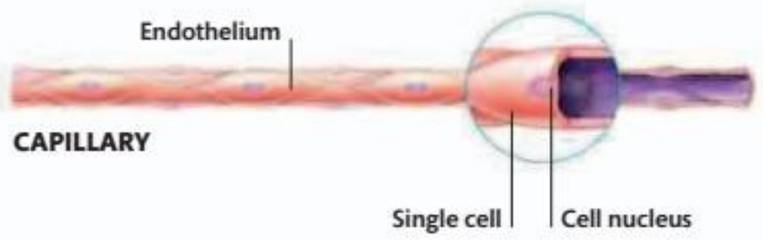
The heart contracts to keep blood moving through a vast network of blood vessels—arteries, arterioles, capillaries, venules, and veins. A thick elastic wall in arteries helps them to carry high-pressure blood from the heart to organs and tissues; veins contain valves that prevent backflow of blood when carrying it back to the heart. Arteries and smaller vessels branch into capillaries—the smallest blood vessels. The endothelial wall of a capillary is one cell thick.



ARTERY



VEIN



CAPILLARY

CARDIOVASCULAR SYSTEM **OVERVIEW**

The cardiovascular system consists of the heart, blood, and blood vessels. The heart—a muscular pump—contracts to push blood through the body's network of vessels in order to deliver oxygen, nutrients, white blood cells, and hormones to the tissues of the body. The blood also removes waste products and takes them to other organs—mainly the liver and kidneys—for excretion. The circulatory system can be divided in two: pulmonary circulation carries blood pumped by the right side of the heart to the lungs, and systemic circulation carries blood pumped by the more powerful left side of the heart to the rest of the body. Pressure in the pulmonary circulation is relatively low, to prevent fluid being forced out of capillaries into the alveoli of the lungs. Pressure in the systemic circulation is much higher, to push blood up to the brain, into all other organs, and out into the fingers and toes.

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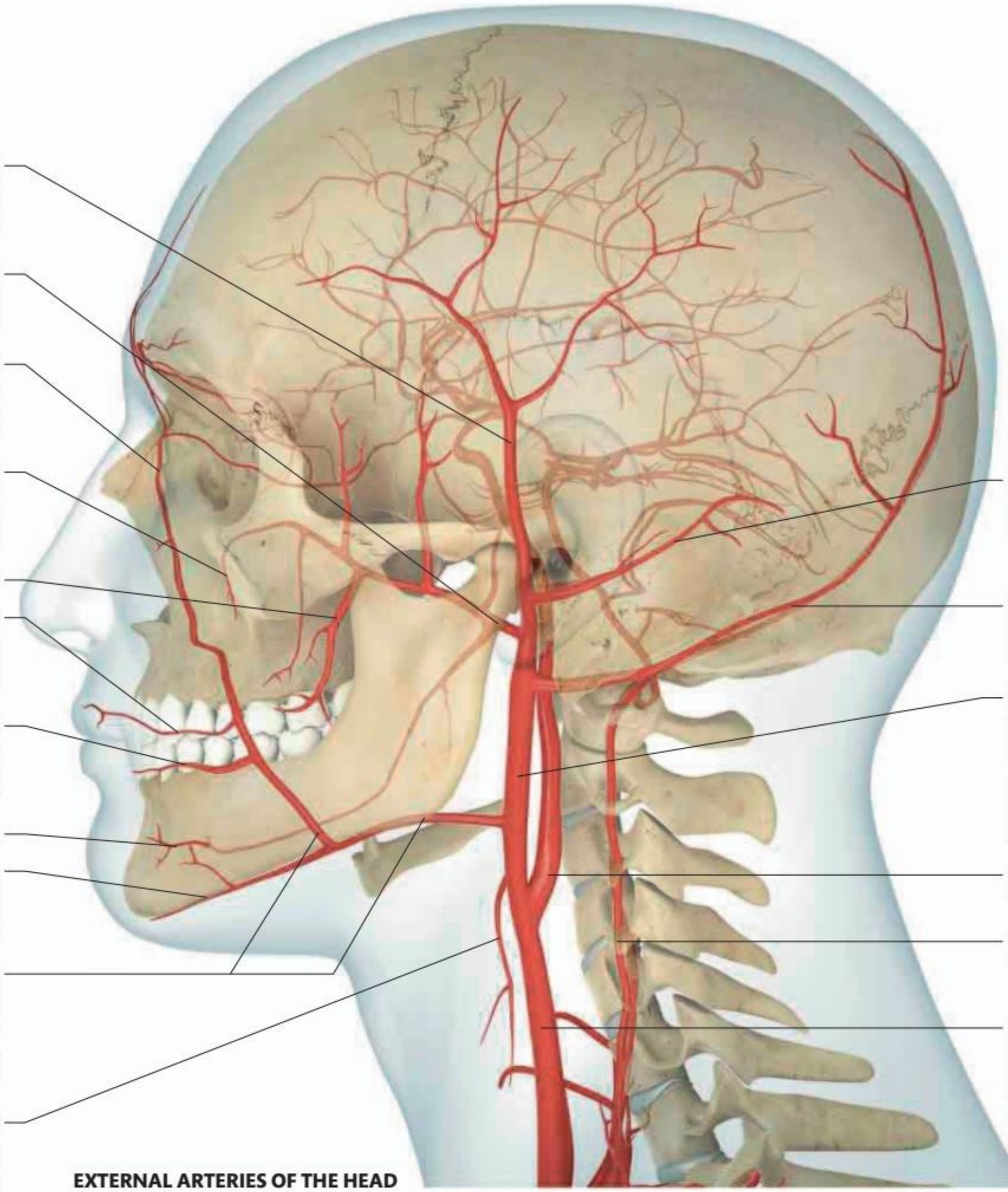
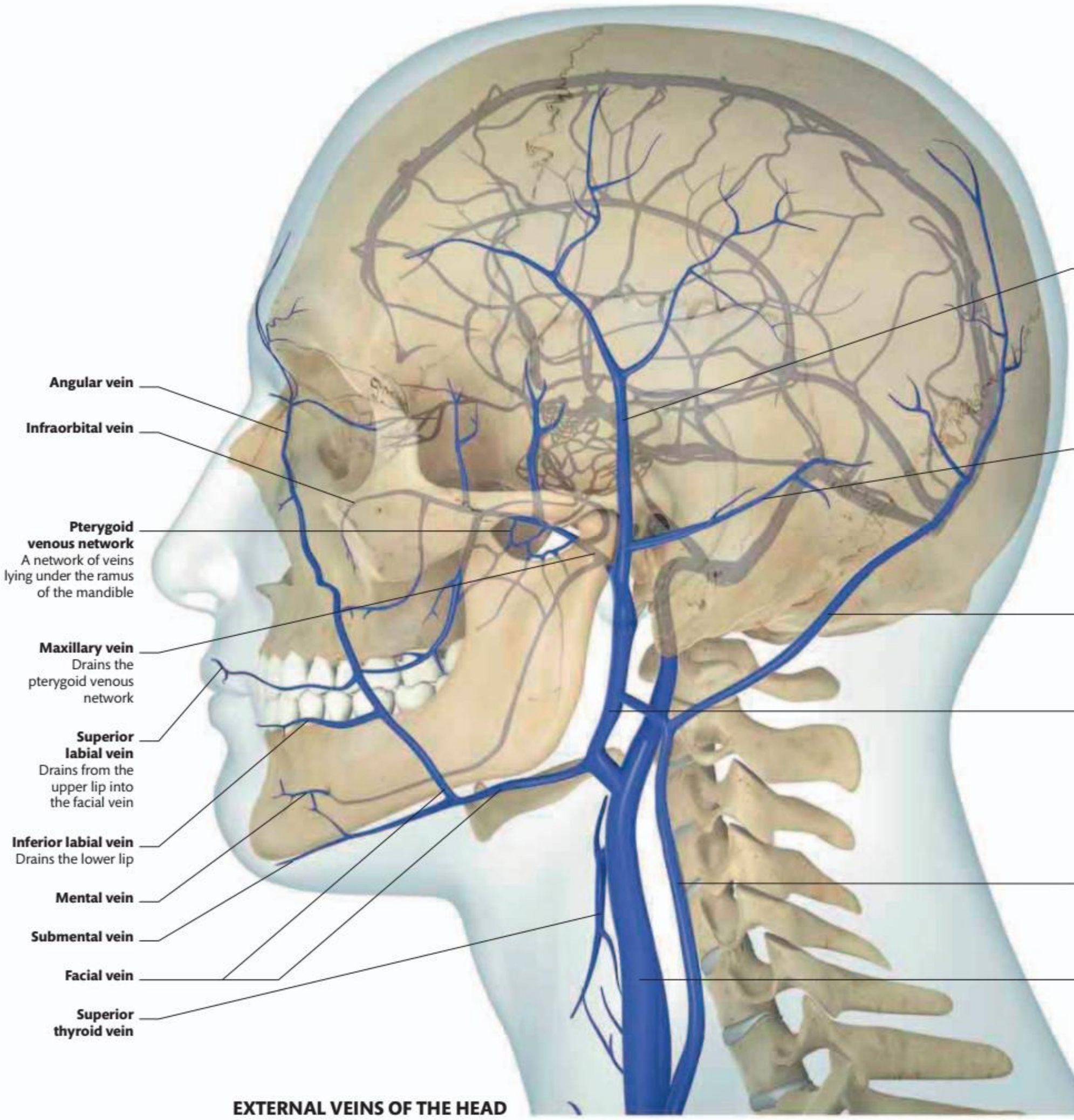


EXTERNAL ARTERIES OF THE HEAD

HEAD AND NECK

The main vessels supplying oxygenated blood to the head and neck are the common carotid and vertebral arteries. The vertebral artery runs up through holes in the cervical vertebrae and eventually enters the skull through the foramen magnum. The common carotid artery runs up the neck and divides in two—the internal carotid artery supplies the brain, and the external carotid artery gives rise to a profusion of branches, some of which supply the thyroid gland, the mouth, tongue, and nasal cavity. Veins of the head and neck come together like river tributaries, draining into the large internal jugular vein, behind the sternocleidomastoid muscle, and into the subclavian vein, low in the neck.



Angular vein

Infraorbital vein

Pterygoid venous network
A network of veins lying under the ramus of the mandible

Maxillary vein
Drains the pterygoid venous network

Superior labial vein
Drains from the upper lip into the facial vein

Inferior labial vein
Drains the lower lip

Mental vein

Submental vein

Facial vein

Superior thyroid vein

Superficial temporal vein
Drains a network of veins in the scalp and ends by joining the maxillary vein to form the retromandibular vein

Posterior auricular vein
Drains the scalp behind the ear; joins the retromandibular vein to form the external jugular vein

Occipital vein
Drains the back of the scalp and runs deep to join other veins

Retromandibular vein
Travels down behind the mandible, through the parotid gland alongside the external carotid artery

External jugular vein
Drains the face and scalp

Internal jugular vein
The largest vein in the neck; lies close to the common carotid artery

EXTERNAL VEINS OF THE HEAD

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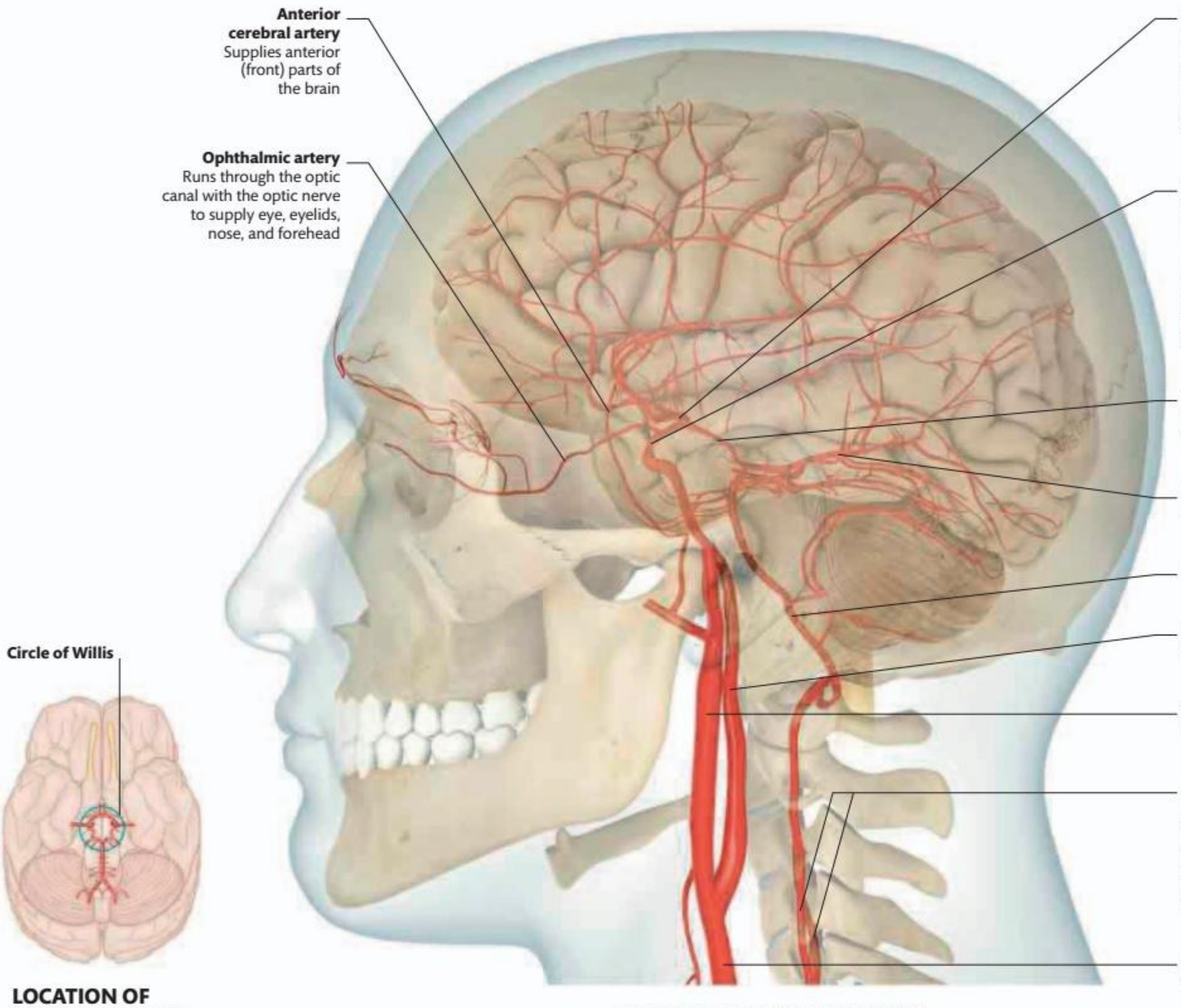
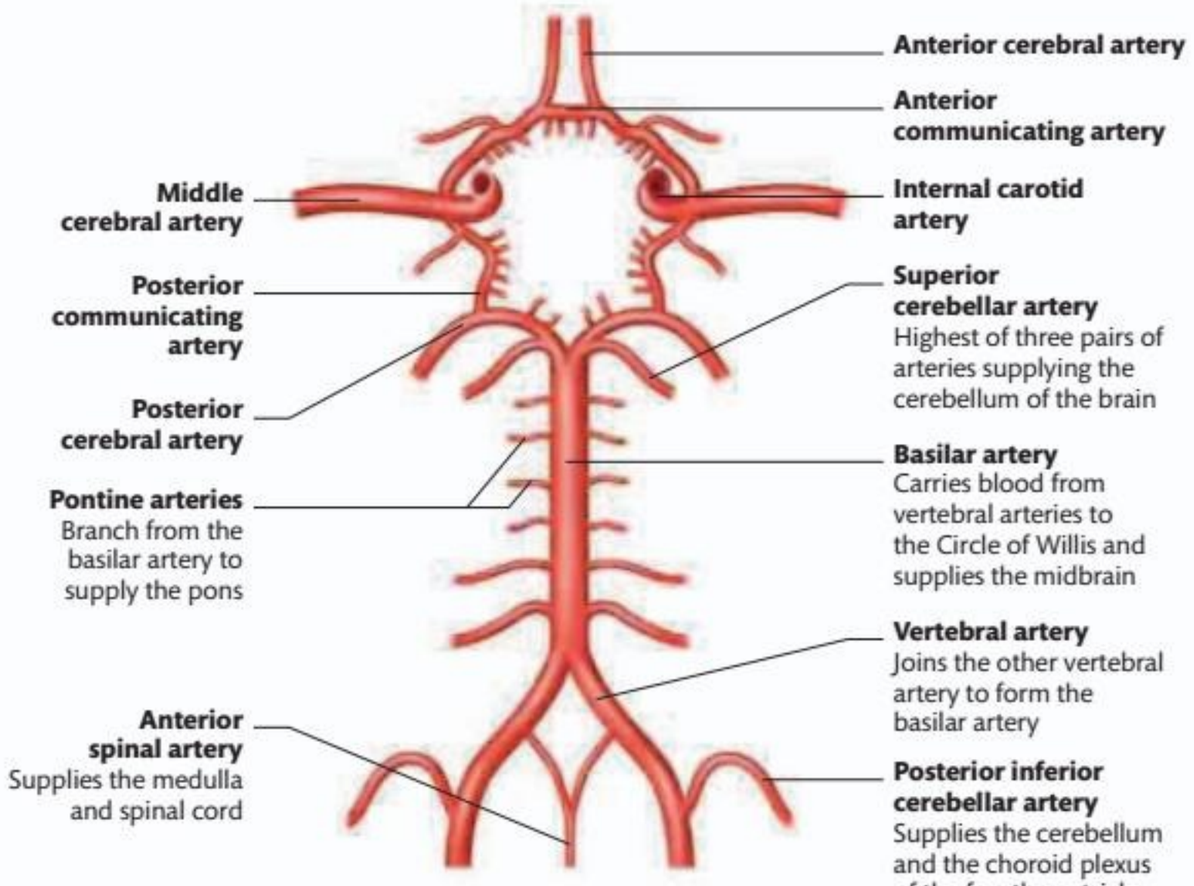


ARTERIES AROUND THE BRAIN

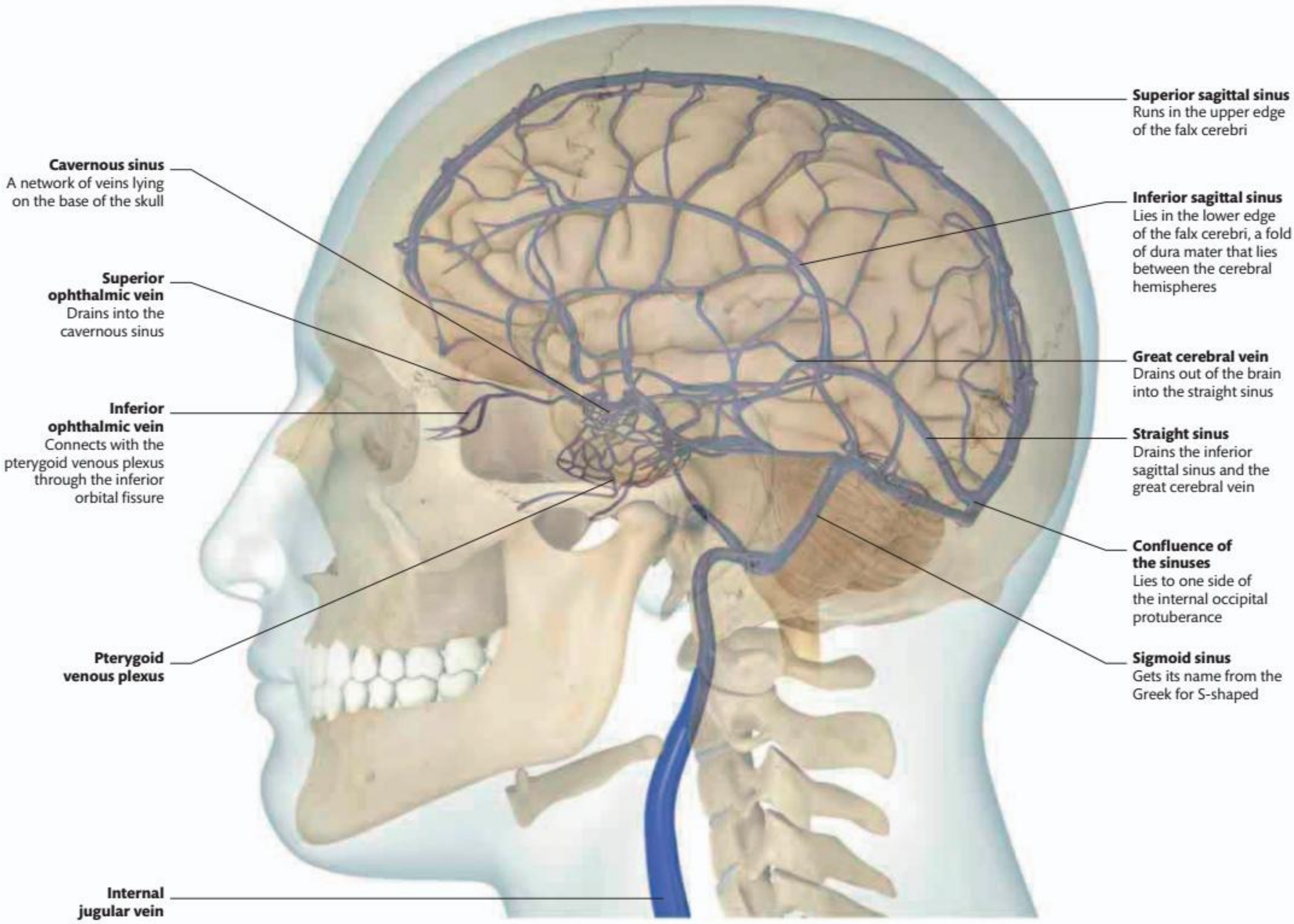
LOCATION OF CIRCLE OF WILLIS

HEAD AND NECK

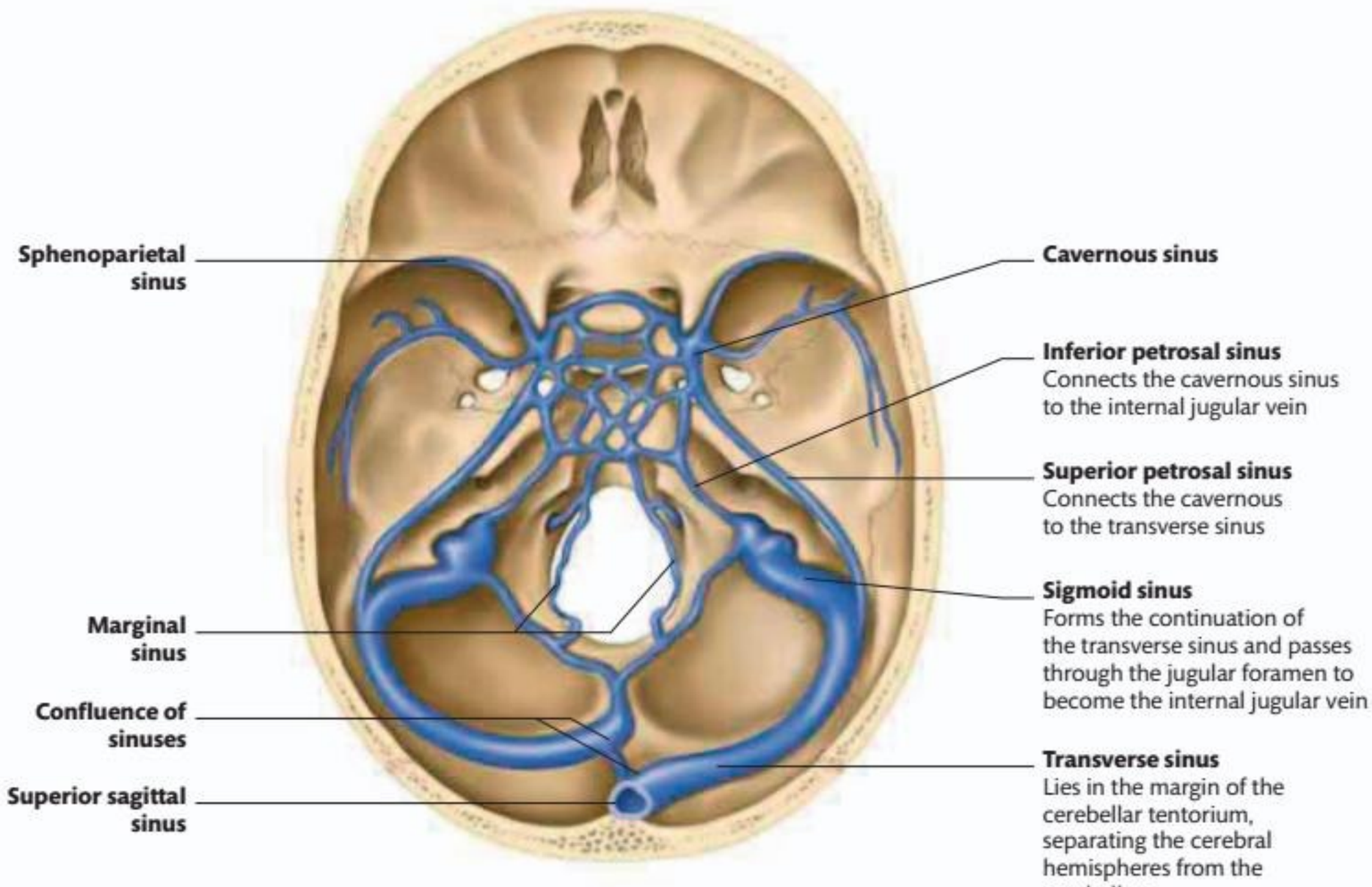
The brain has a rich blood supply, which arrives via the internal carotid and vertebral arteries. The vertebral arteries join together to form the basilar artery. The internal carotid arteries and basilar artery join up on the undersurface of the brain to form the Circle of Willis. From there, three pairs of cerebral arteries make their way into the brain. The veins of the brain and the skull drain into venous sinuses, which are enclosed within the dura mater (the outermost layer of the meninges) and form grooves on the inner surface of the skull. The sinuses join up and eventually drain out of the base of the skull, into the internal jugular vein.



CIRCLE OF WILLIS



VEINS AROUND THE BRAIN



DURAL VENOUS SINUSES

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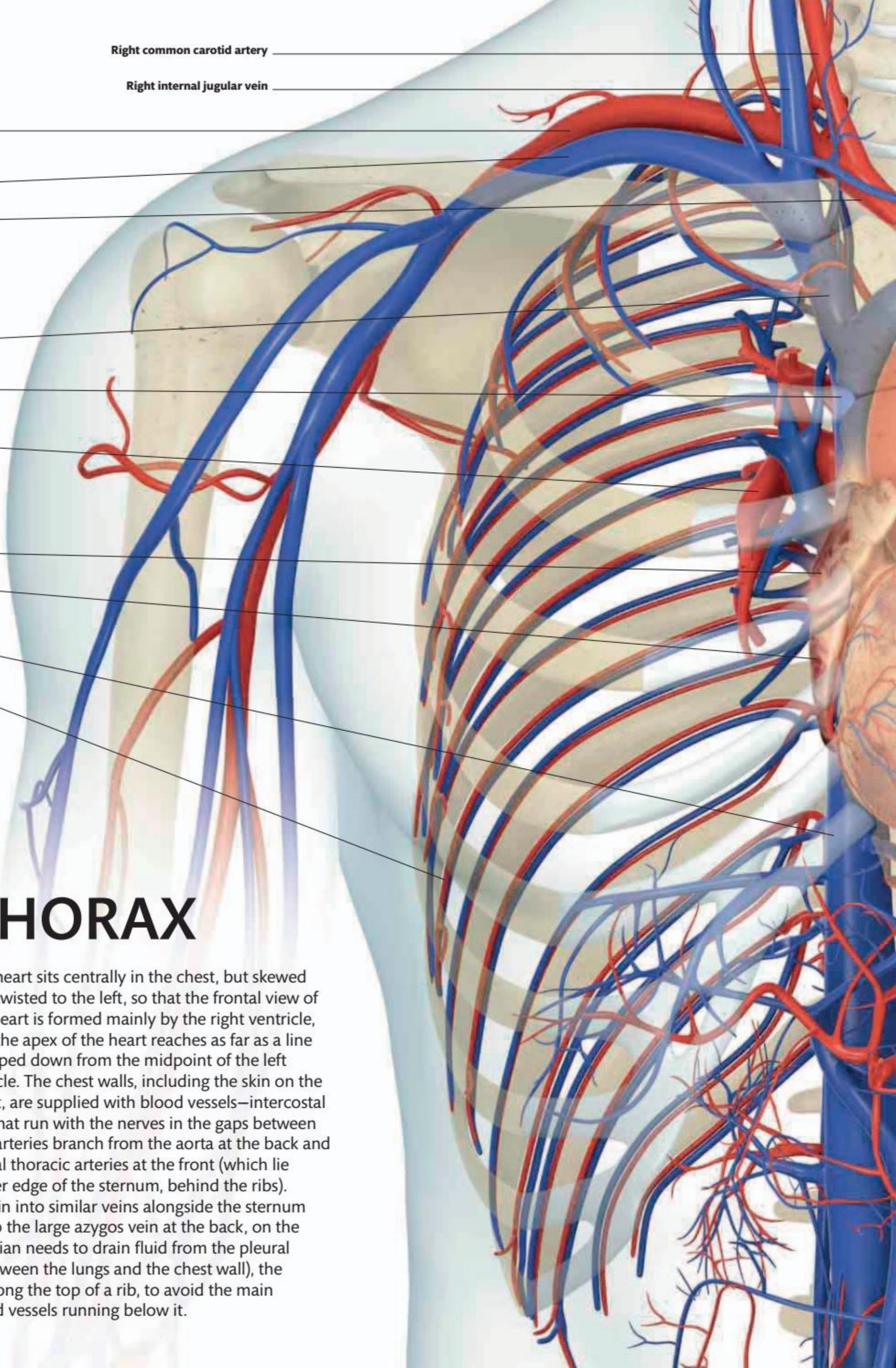


THORAX

The heart sits centrally in the chest, but skewed and twisted to the left, so that the frontal view of the heart is formed mainly by the right ventricle, and the apex of the heart reaches as far as a line dropped down from the midpoint of the left clavicle. The chest walls, including the skin on the chest, are supplied with blood vessels—intercostal arteries and veins—that run with the nerves in the gaps between the ribs. Intercostal arteries branch from the aorta at the back and from the two internal thoracic arteries at the front (which lie vertically along either edge of the sternum, behind the ribs). Intercostal veins drain into similar veins alongside the sternum at the front, and into the large azygos vein at the back, on the right side. If a physician needs to drain fluid from the pleural cavity (the space between the lungs and the chest wall), the needle is inserted along the top of a rib, to avoid the main intercostal nerve and vessels running below it.

Left common carotid artery
On the left side of the body this branches directly from the arch of the aorta (compare with right)

Left internal jugular vein

Left subclavian artery

Left subclavian vein

Left brachiocephalic vein

Arch of aorta
The main artery of the body exits the heart and arches over it

Left pulmonary artery

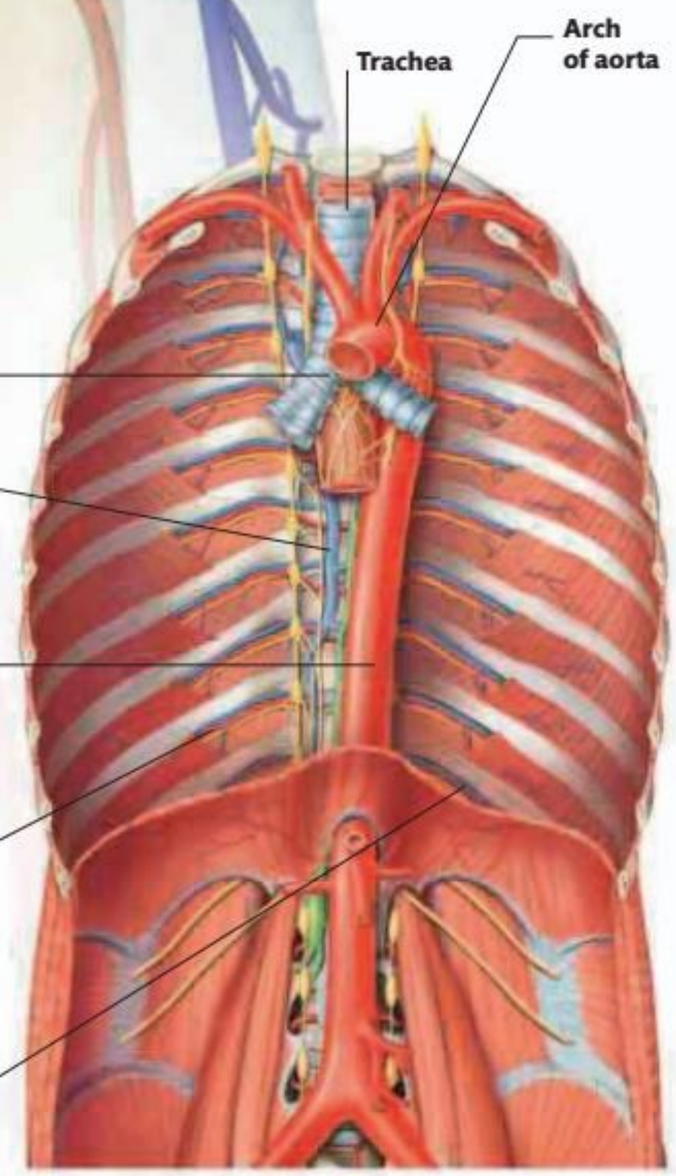
Ascending aorta

Pulmonary trunk
Branches into the right and left pulmonary arteries, under the arch of the aorta

Left auricle

Right ventricle

ANTERIOR (FRONT)



BACK OF THORACIC CAVITY (HEART REMOVED)

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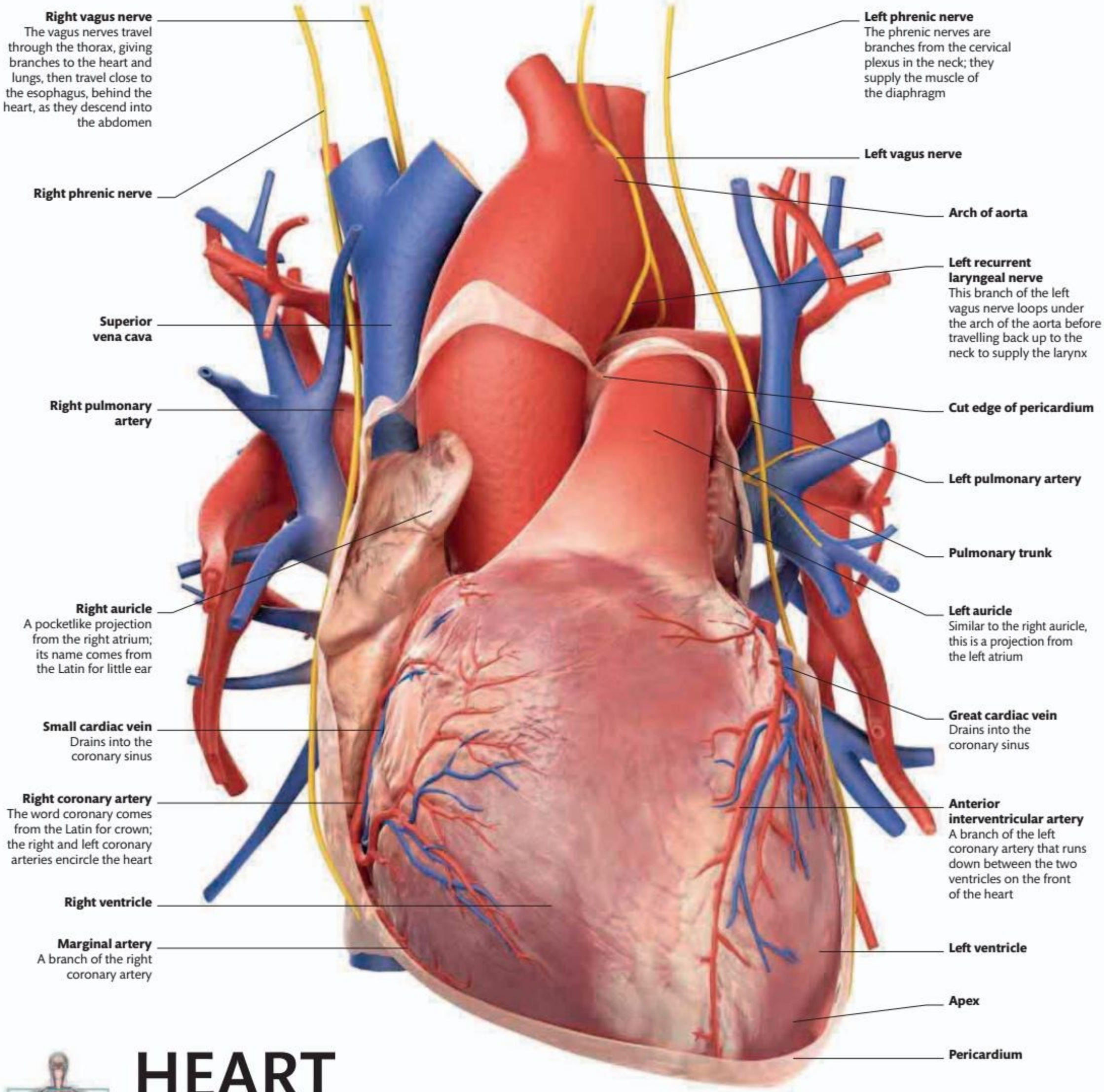
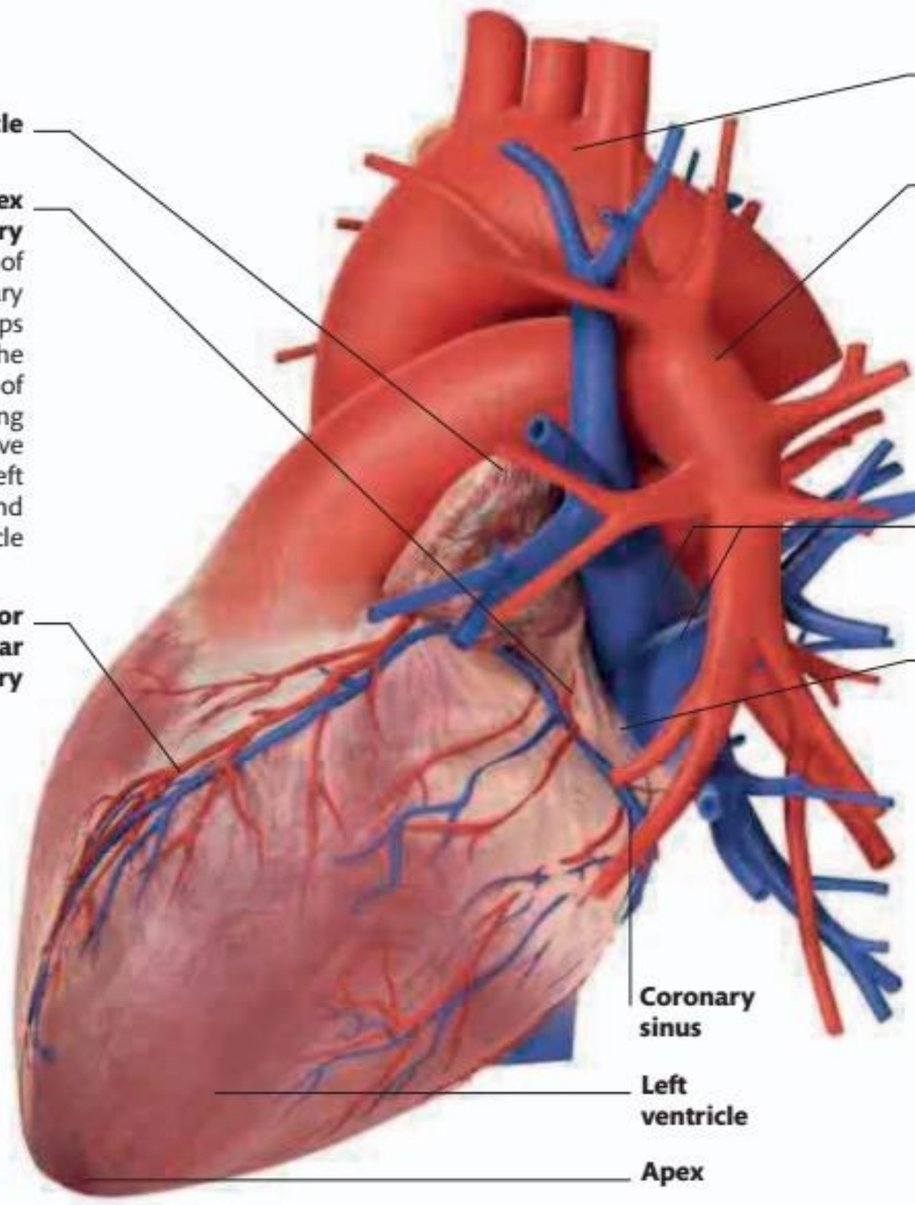


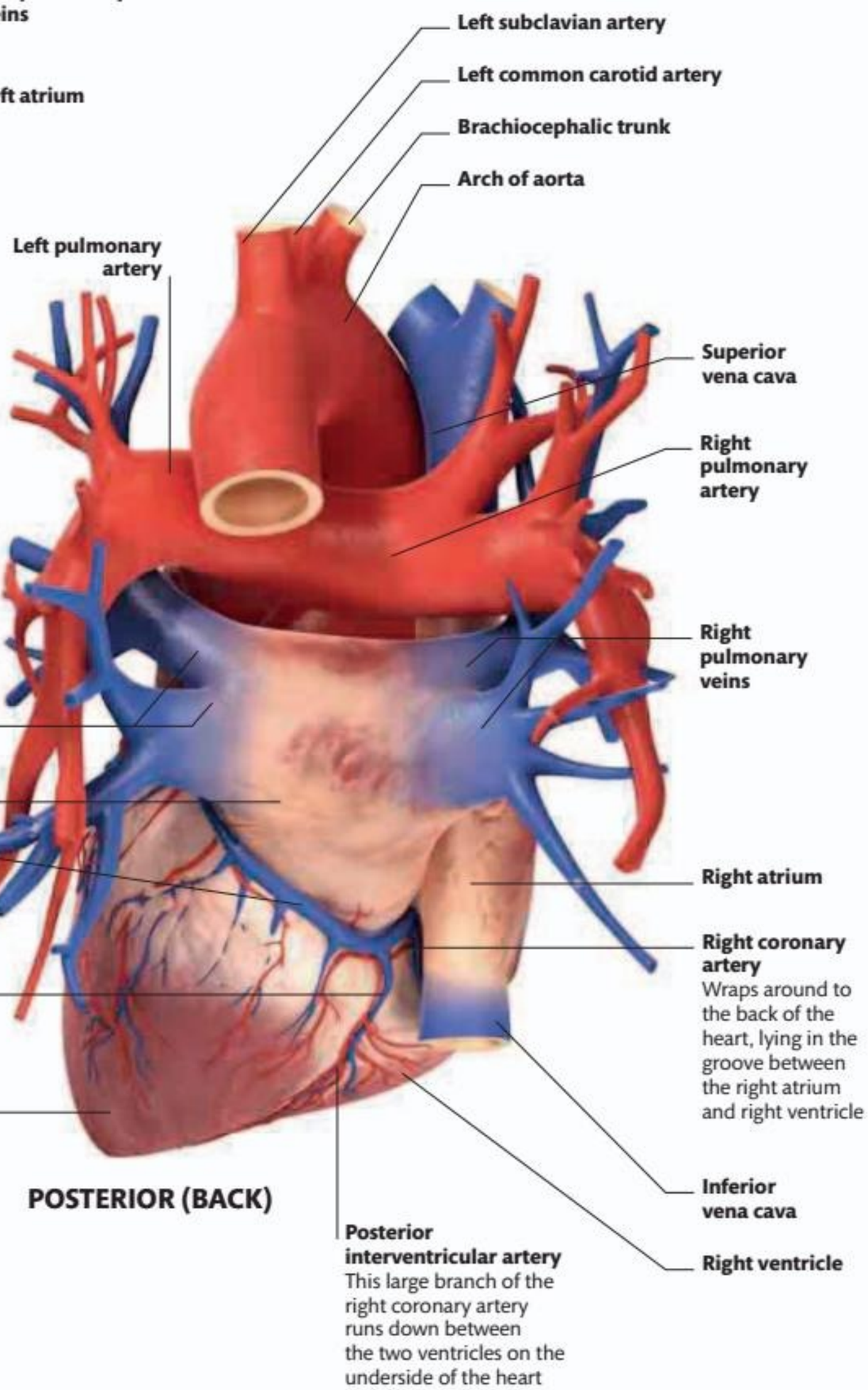
ANTERIOR (FRONT)

HEART

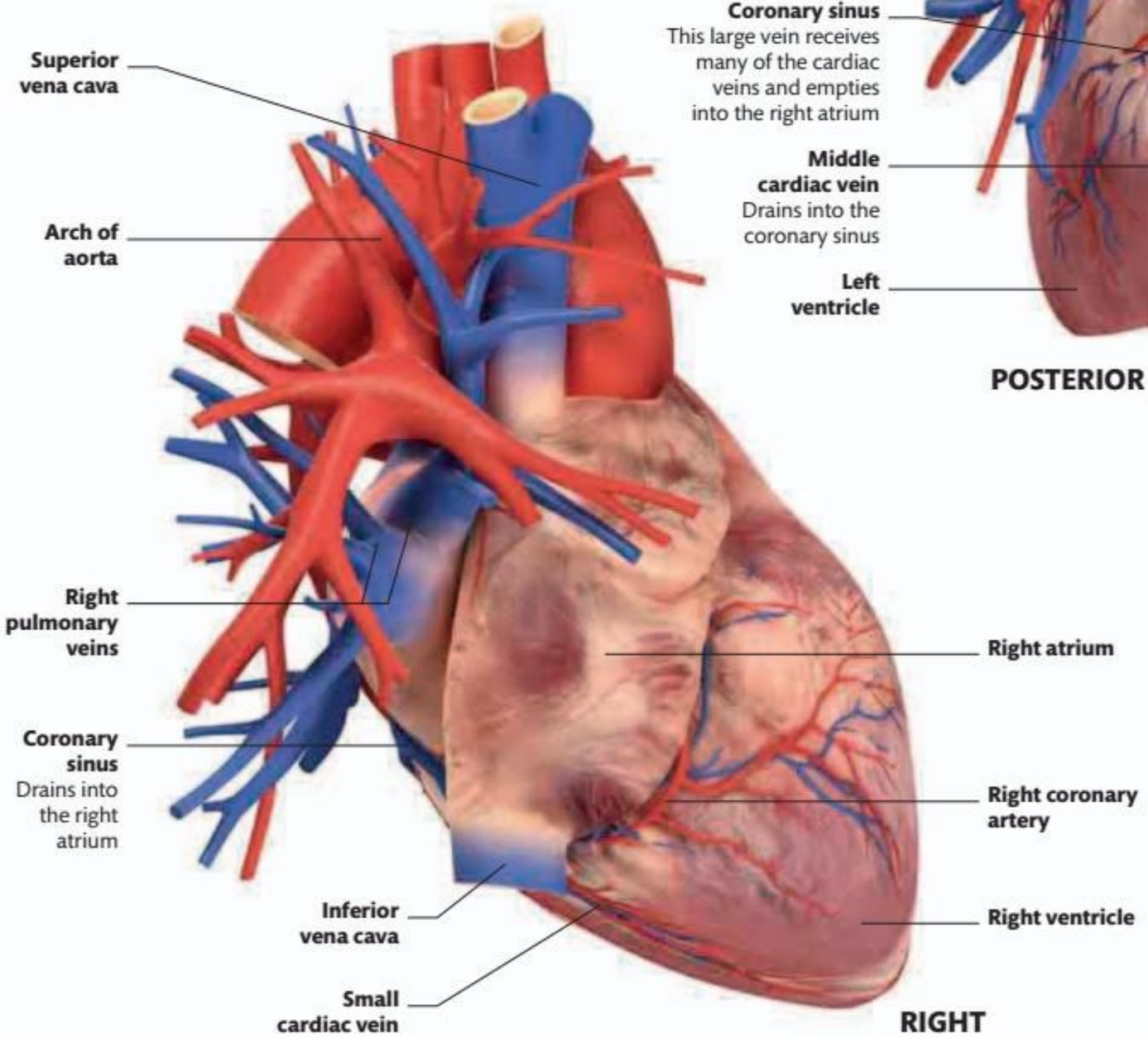
The heart is encased in the pericardium. This has a tough outer layer that is fused to the diaphragm below and to the connective tissue around the large blood vessels above the heart. Lining the inside of this cylinder (and the outer surface of the heart) is a thin membrane called the serous pericardium. Between these two layers is a thin film of fluid that lubricates the movement of the heart as it beats. Inflammation of this membrane, known as pericarditis, can be extremely painful. Branches of the right and left coronary arteries, which spring from the ascending aorta, supply the heart muscle itself. The heart is drained by cardiac veins, most of which drain into the coronary sinus.



LEFT



POSTERIOR (BACK)



RIGHT

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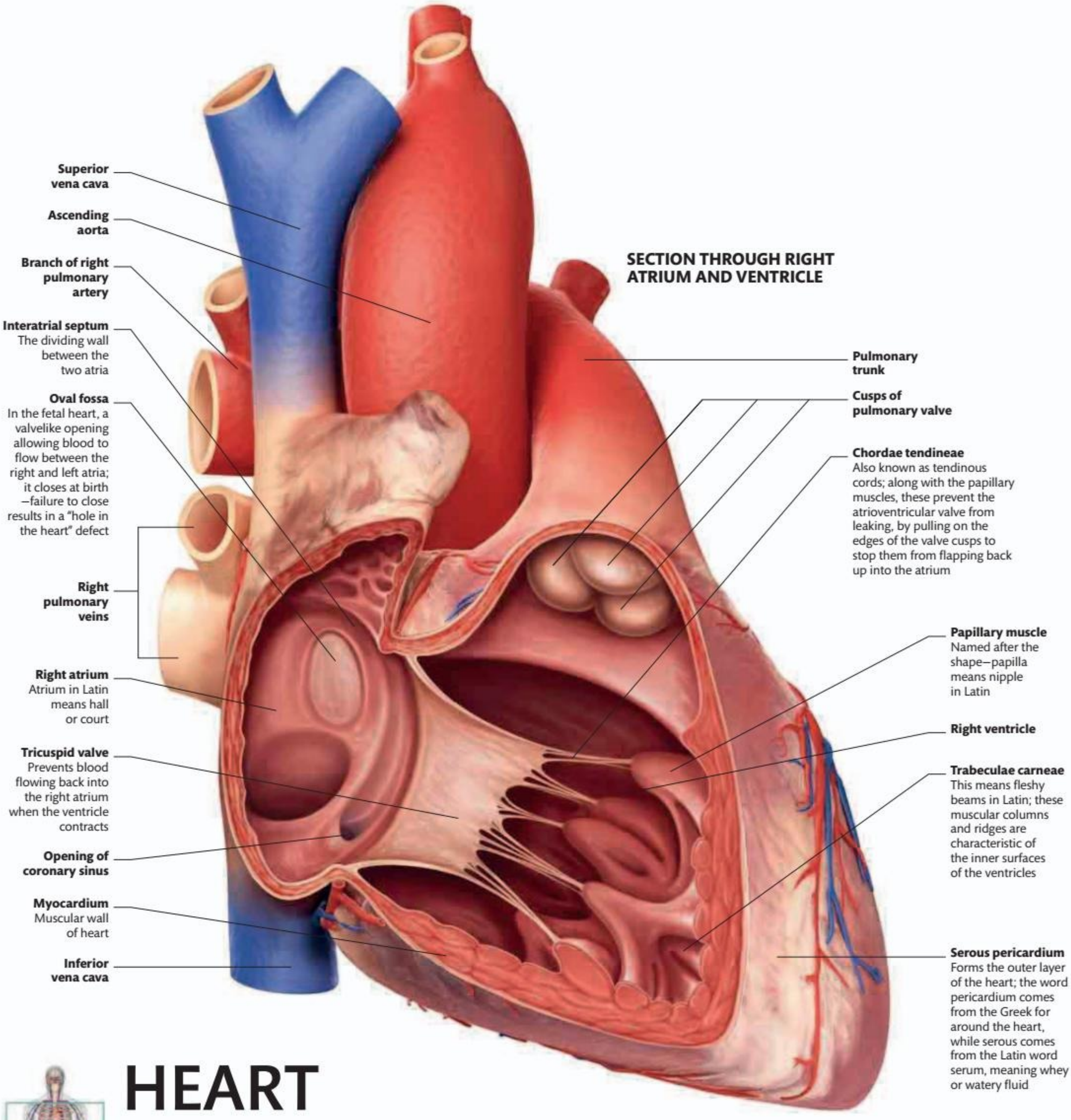
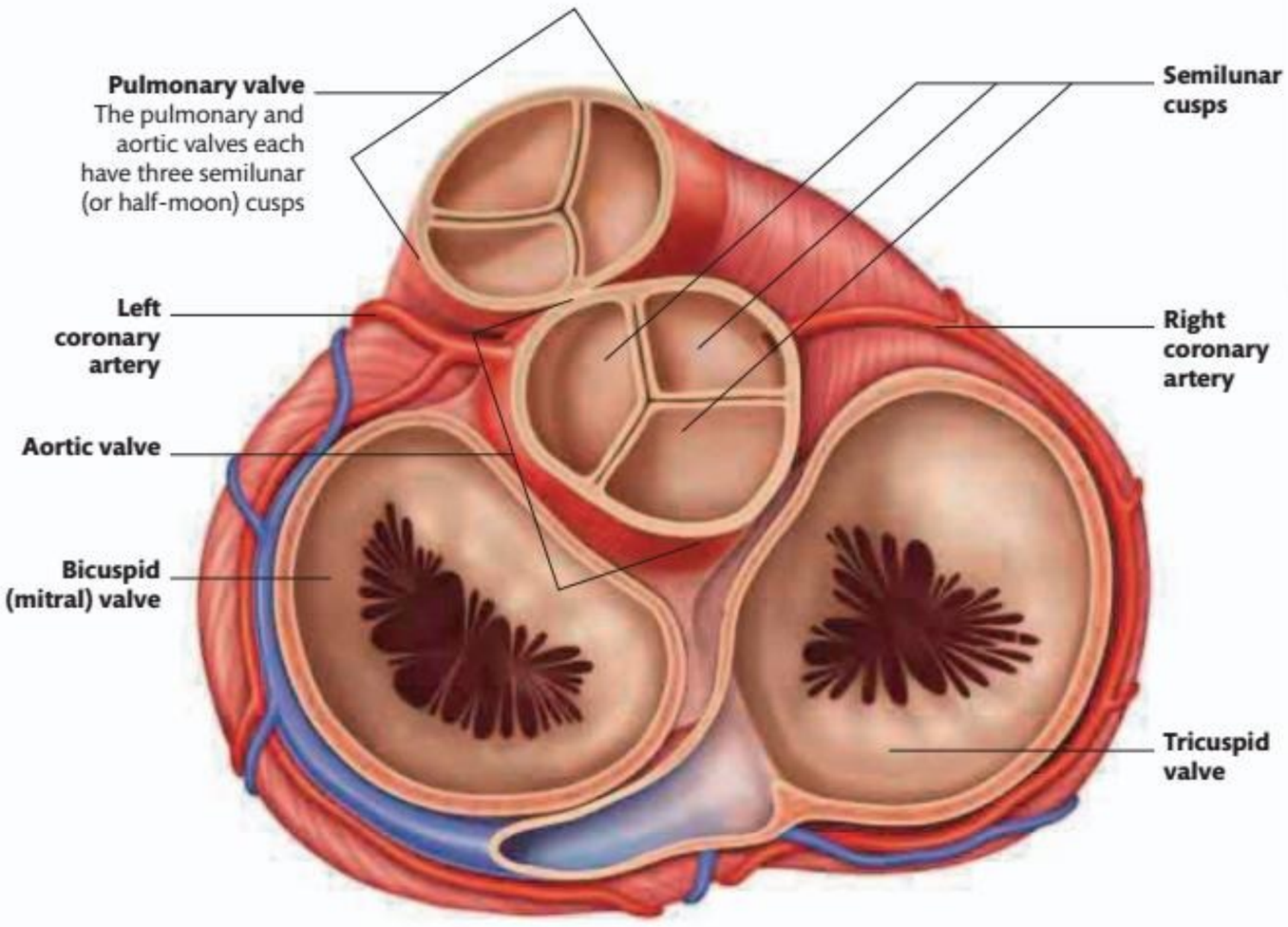


HEART

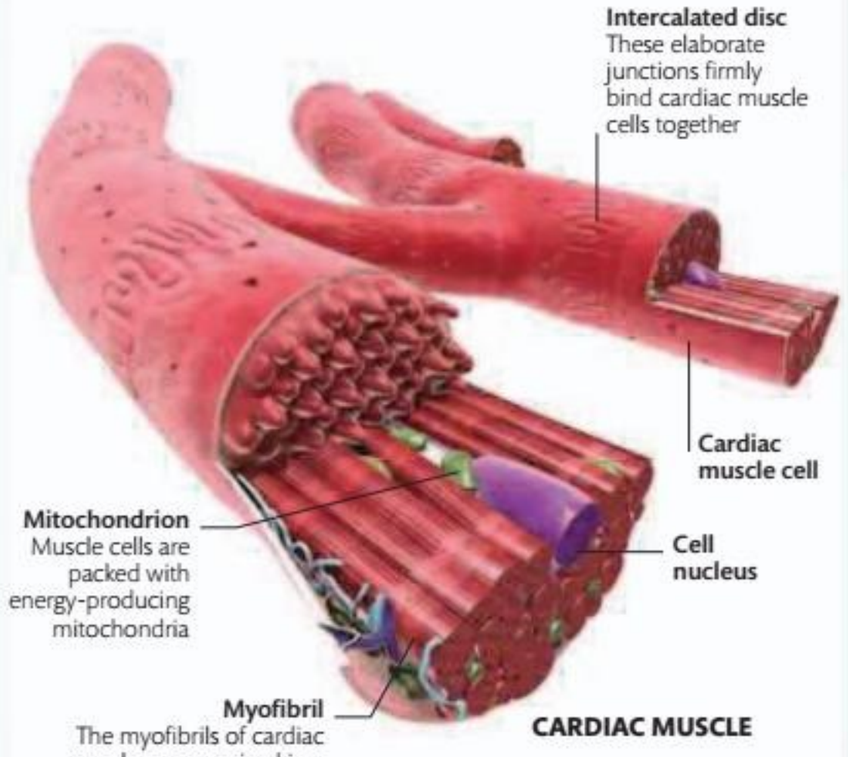
The heart receives blood from veins and pumps it out through arteries. It has four chambers: two atria and two ventricles. The heart's left and right sides are separate. The right side receives deoxygenated blood from the body via the superior and inferior venae cavae, and pumps it to the lungs through the pulmonary trunk. The left gets oxygenated blood from the lungs via the pulmonary veins, and pumps it into the aorta for distribution. Each atrium opens into its corresponding ventricle via a valve (on the right, the tricuspid valve, and the bicuspid valve on the left), which shuts when the ventricle contracts, to stop blood flowing back into the atrium. The aorta and pulmonary trunk also have valves.



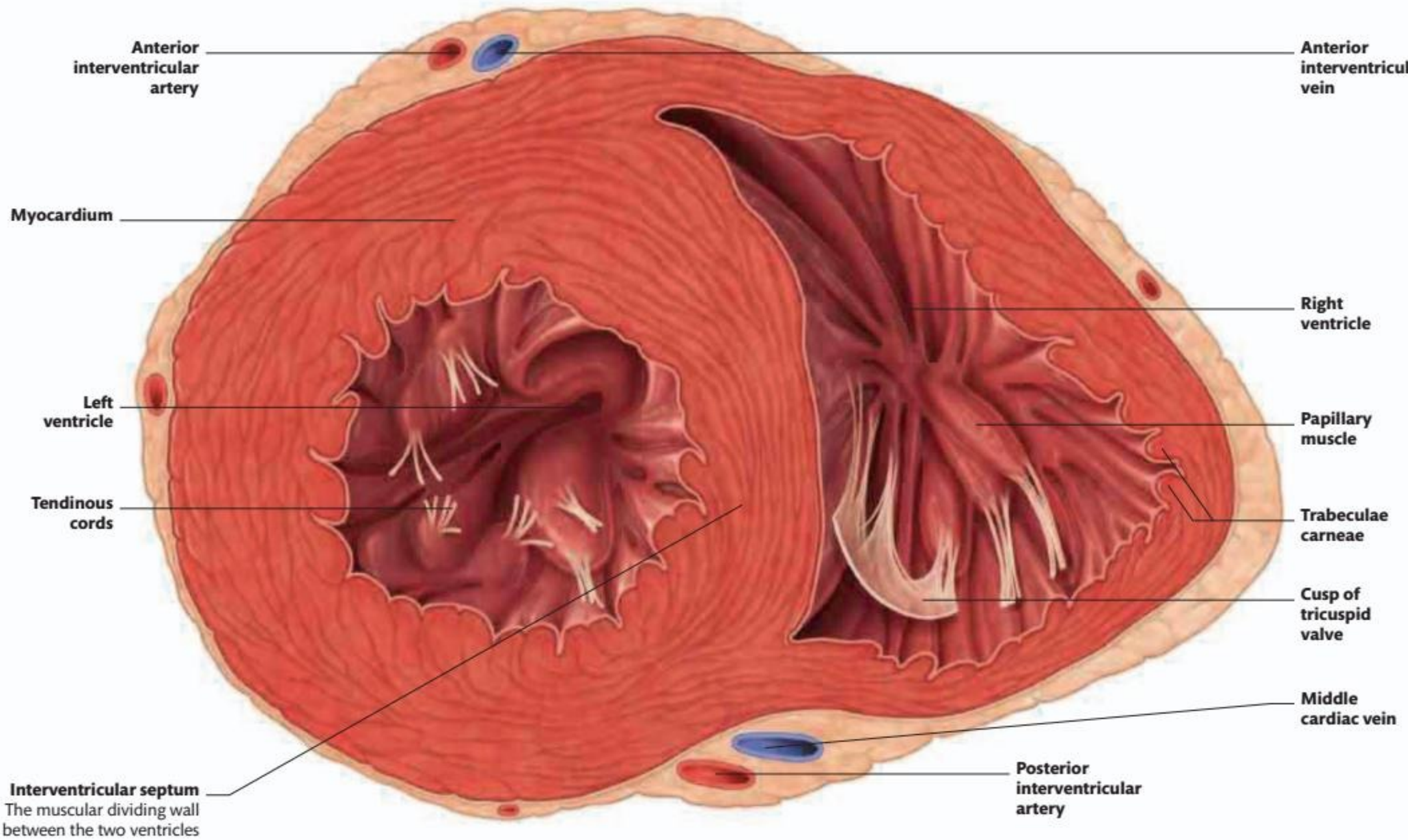
TRANSVERSE SECTION SHOWING VALVES

CARDIAC MUSCLE STRUCTURE

Cardiac muscle (myocardium) is essential to the heart's function as a pump. When the myocardium contracts, blood is squeezed out of the heart. The myocardium is a network of interconnected fibers, which contract rhythmically and spontaneously. Autonomic nerves can adjust the rate of contraction, matching the heart's output to the body's need.



CARDIAC MUSCLE



TRANSVERSE SECTION THROUGH VENTRICLES

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ABDOMEN AND PELVIS

The aorta passes behind the diaphragm, level with the twelfth thoracic vertebra, and enters the abdomen. Pairs of arteries branch from the sides of the aorta to supply the walls of the abdomen, the kidneys, suprarenal glands, and the testes or ovaries with oxygenated blood. A series of branches emerge from the front of the abdominal aorta to supply the abdominal organs: the celiac trunk gives branches to the liver, stomach, pancreas, and spleen, and the mesenteric arteries provide blood to the gut. The abdominal aorta ends by splitting into two, forming the common iliac arteries. Each of these then divides, in turn, forming an internal iliac artery (which supplies the pelvic organs) and an external iliac artery (which continues into the thigh, becoming the femoral artery). Lying to the right of the aorta is the major vein of the abdomen: the inferior vena cava.

Right hepatic artery

Portal vein
Carries blood from the intestines to the liver; formed from the joining of the splenic and superior mesenteric veins

Common hepatic artery
Branches into right and left hepatic arteries

Right renal artery
Supplies the right kidney

Right renal vein
Drains the right kidney

Superior mesenteric vein
Drains blood from the small intestine, cecum, and half of the colon, and ends by joining the splenic vein to form the portal vein

Inferior vena cava

Ileocolic artery
Branch of the superior mesenteric artery supplying the end of the ileum, the cecum, the start of the ascending colon, and the appendix

Right common iliac vein

Right common iliac artery
Divides into the right external and internal iliac arteries

Right internal iliac artery
Provides branches to the bladder, rectum, perineum, and external genitals, muscles of the inner thigh, bone of the ilium and sacrum, and the buttock, as well as the uterus and vagina in a woman

Right internal iliac vein

Right external iliac artery
Gives a branch to the lower part of the anterior abdominal wall before passing over the pubic bone and under the inguinal ligament to become the femoral artery

Right superior gluteal artery
The largest branch of the internal iliac artery; passes out through the back of the pelvis to supply the upper buttock

Right external iliac vein

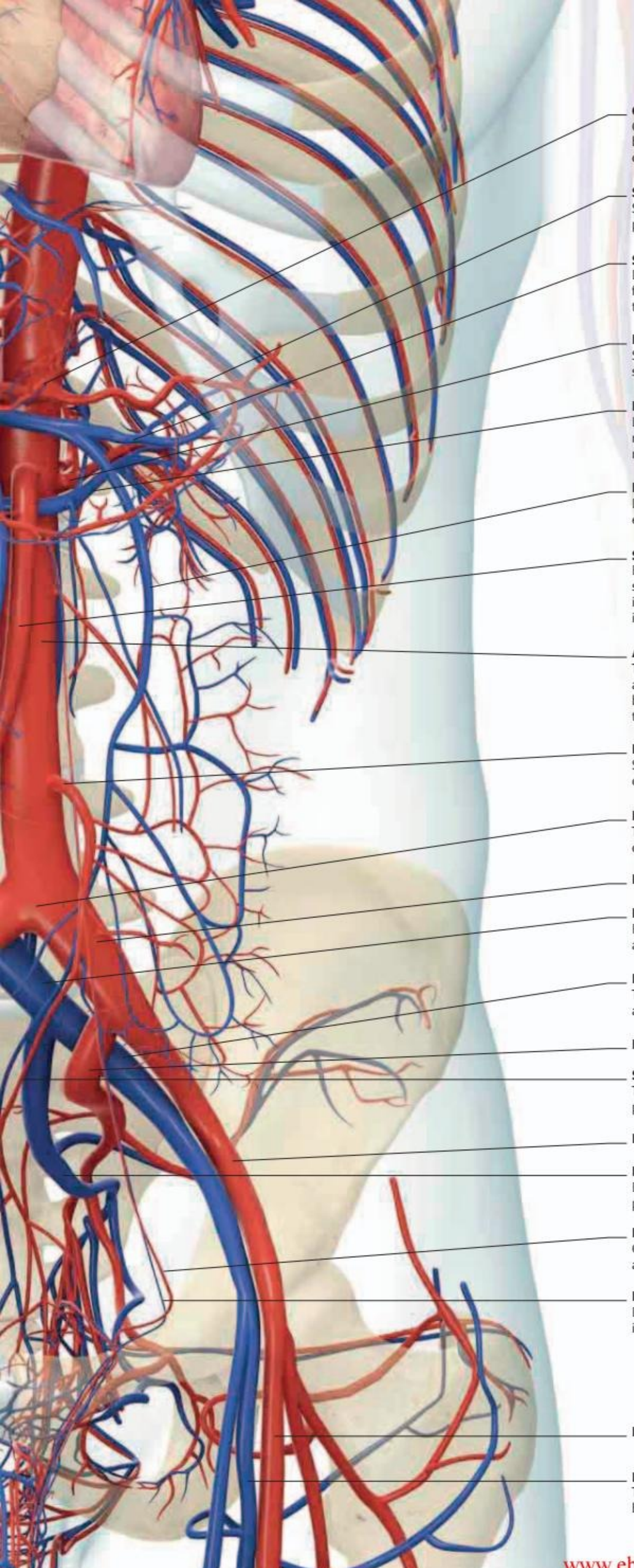
Right gonadal artery
In a woman, supplies the ovary on each side; in a man, extends to the scrotum to supply the testis

Right gonadal vein
Drains the ovary or testis and ends by joining the inferior vena cava

Right femoral artery
The main artery of the leg; the continuation of the external iliac artery in the thigh

Right femoral vein

ANTERIOR (FRONT)



Celiac trunk
Only just over ⅜in (1cm) long, it quickly branches into the left gastric, splenic, and common hepatic arteries

Splenic artery
Supplies the spleen, as well as most of the pancreas, and the upper part of the stomach

Splenic vein
Drains the spleen and receives other veins from the stomach and pancreas, as well as the inferior mesenteric vein

Left renal artery
Shorter than the right renal artery, this supplies the left kidney

Left renal vein
Longer than its counterpart on the right, this drains the left kidney and receives the left gonadal vein

Inferior mesenteric vein
Drains blood from the colon and rectum and ends by emptying into the splenic vein

Superior mesenteric artery
Branches within the mesentery to supply a great length of intestine, including all of the jejunum and ileum and half of the colon

Abdominal aorta
The thoracic aorta becomes the abdominal aorta as it passes behind the diaphragm, level with the twelfth thoracic vertebra

Inferior mesenteric artery
Supplies the last third of the transverse colon, the descending and sigmoid colon, and the rectum

Bifurcation of aorta
The abdominal aorta divides in front of the fourth lumbar vertebra

Left common iliac artery

Left common iliac vein
Formed from the union of the external and internal iliac veins

Left external iliac vein
The continuation of the femoral vein, after it has passed into the pelvis

Left internal iliac artery

Superior rectal artery
The last branch of the inferior mesenteric artery passes down into the pelvis to supply the rectum

Left external iliac artery

Left internal iliac vein
Drains the pelvic organs, perineum, and buttock

Left gonadal artery
Gonadal arteries branch from the aorta just below the renal arteries

Left gonadal vein
Drains the ovary or testis, and empties into the left renal vein

Left femoral artery

Left femoral vein
The main vein from the leg; becomes the external iliac vein

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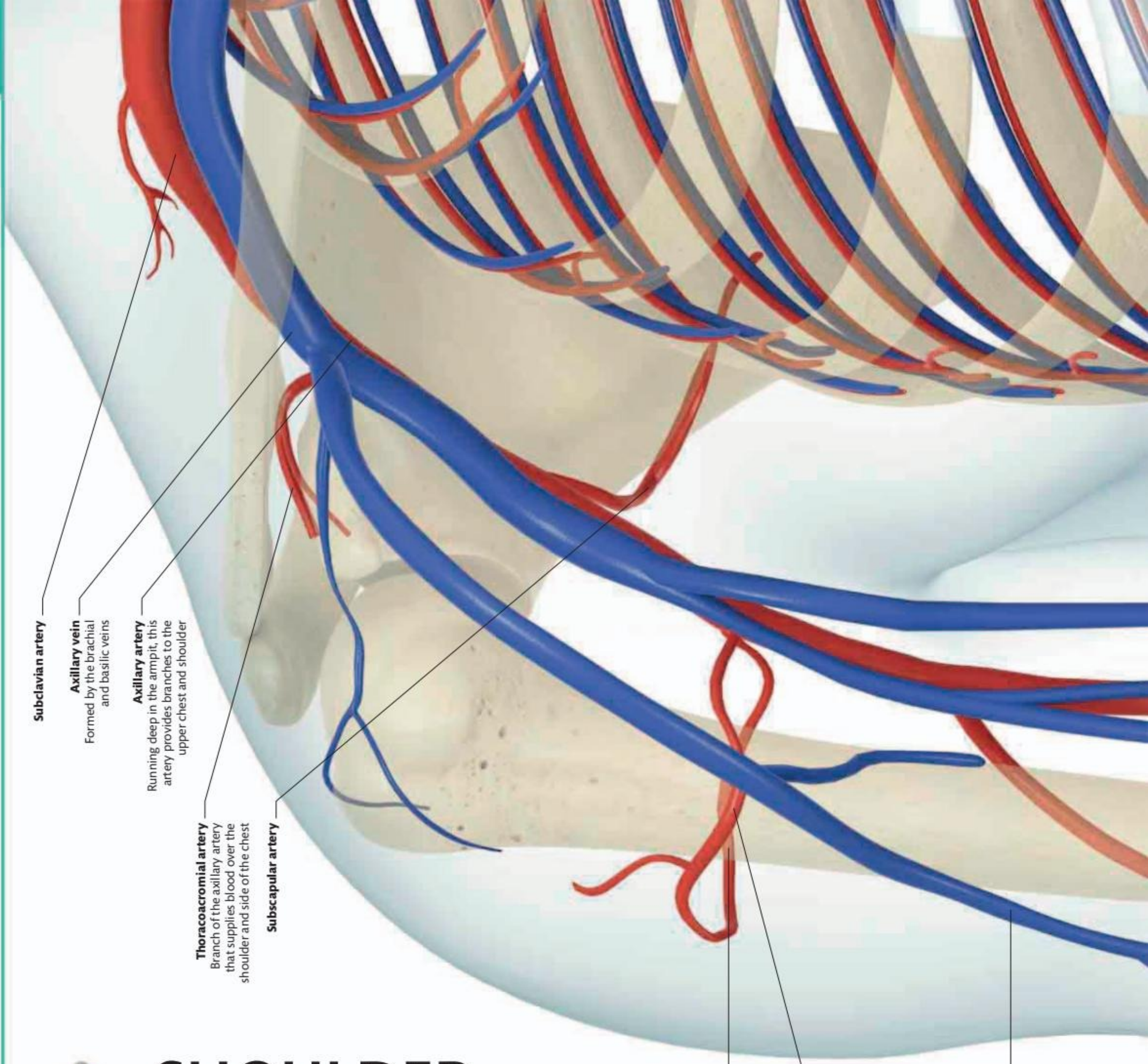
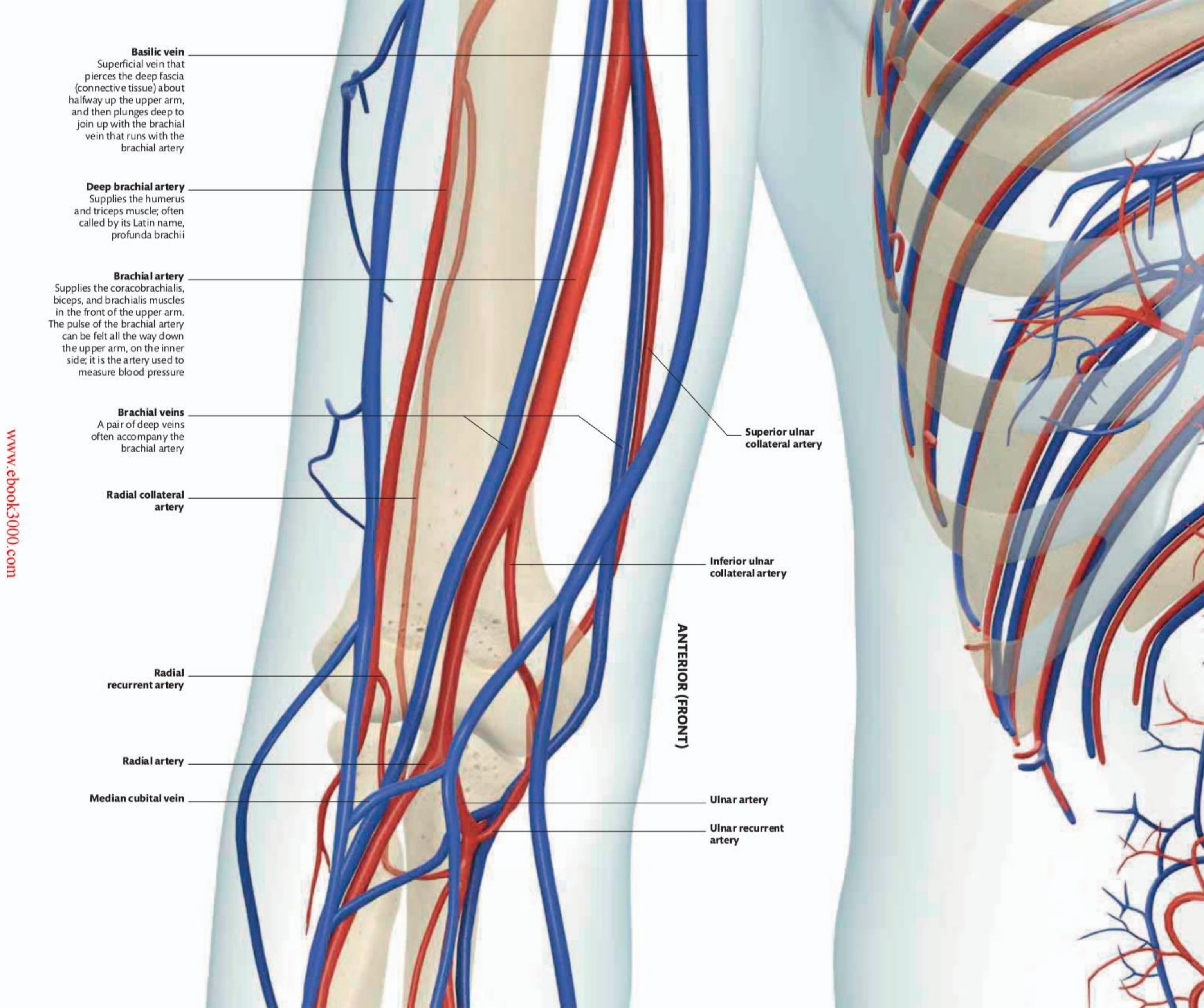


SHOULDER AND UPPER ARM

The subclavian artery is the main arterial supply to the upper limb. When this artery passes under the clavicle and into the axilla (armpit), it becomes the axillary artery. Several branches spring off in this region, running backward toward the scapula, up to the shoulder, and around the humerus. Beyond the armpit, the name of the axillary artery changes to the brachial artery, which runs down the front of the arm, usually accompanied by a pair of companion veins. Two superficial veins that drain blood from the back of the hand end in the arm by draining into deep veins: the basilic vein drains into brachial veins; the cephalic vein runs up to the shoulder, then plunges deeper to join the axillary vein.



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SHOULDER AND UPPER ARM

Various branches from the axillary and brachial arteries supply the back of the shoulder and upper arm. The posterior circumflex humeral artery, which runs with the axillary nerve, curls around the upper end of the humerus. The deep brachial artery runs with the radial nerve, spiraling around the back of the bone. From this artery, and from the brachial artery itself, collateral branches run down the arm and join up, or anastomose, with recurrent branches running back up from the ulnar and radial arteries of the forearm. There are also anastomoses (links) between branches of the subclavian and axillary arteries around the shoulder. Anastomoses like this, where branches from different regions join up, can provide alternative routes through which blood can flow if the main vessel becomes squashed or blocked.

Brachial artery

Posterior circumflex humeral artery

Anterior circumflex humeral artery

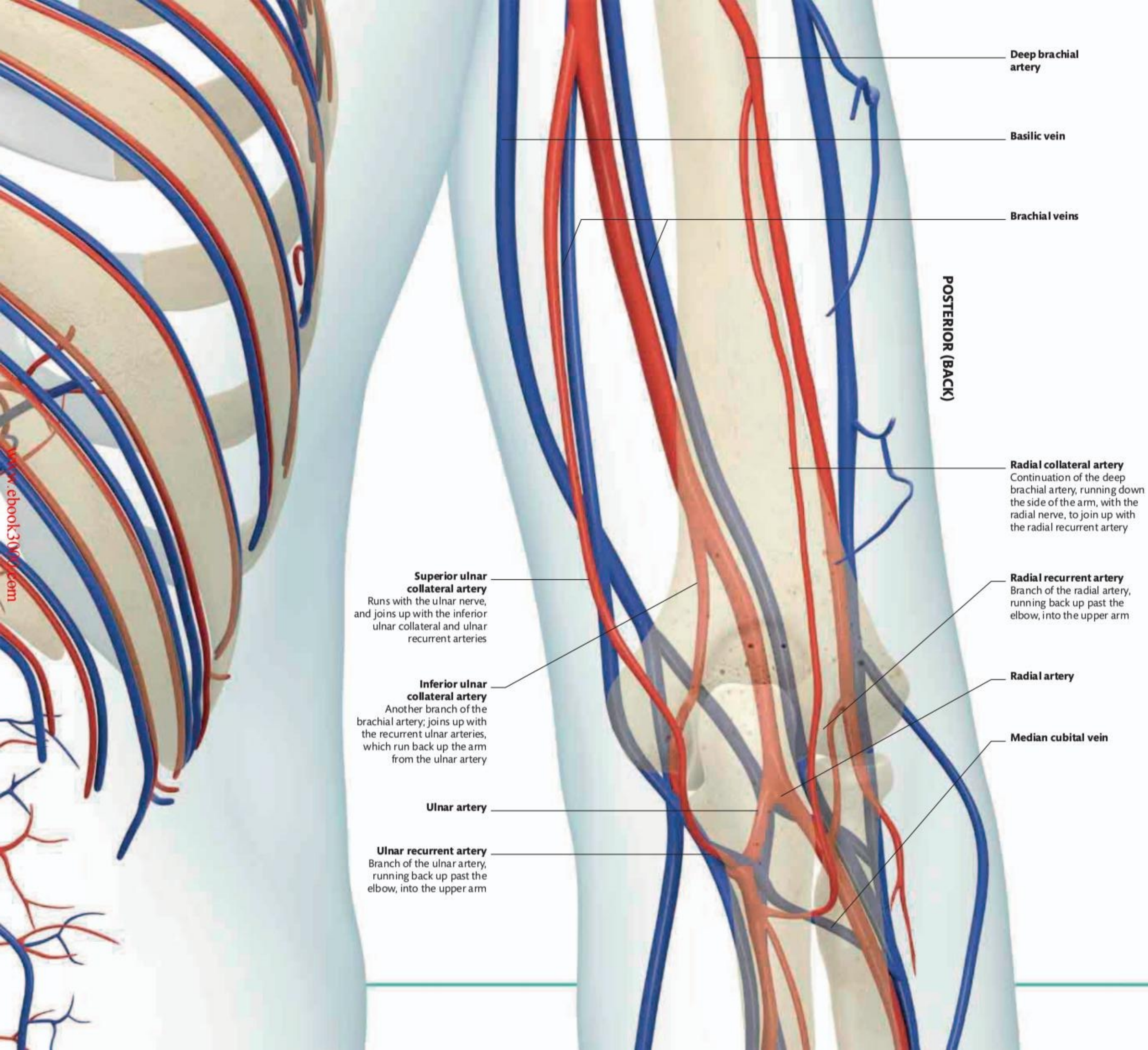
Cephalic vein

Thoracoacromial artery

Subscapular artery
Largest branch of the axillary artery; runs under the edge of the scapula, supplying subscapularis muscle, and sends branches around the back of the scapula

Axillary vein

Axillary artery



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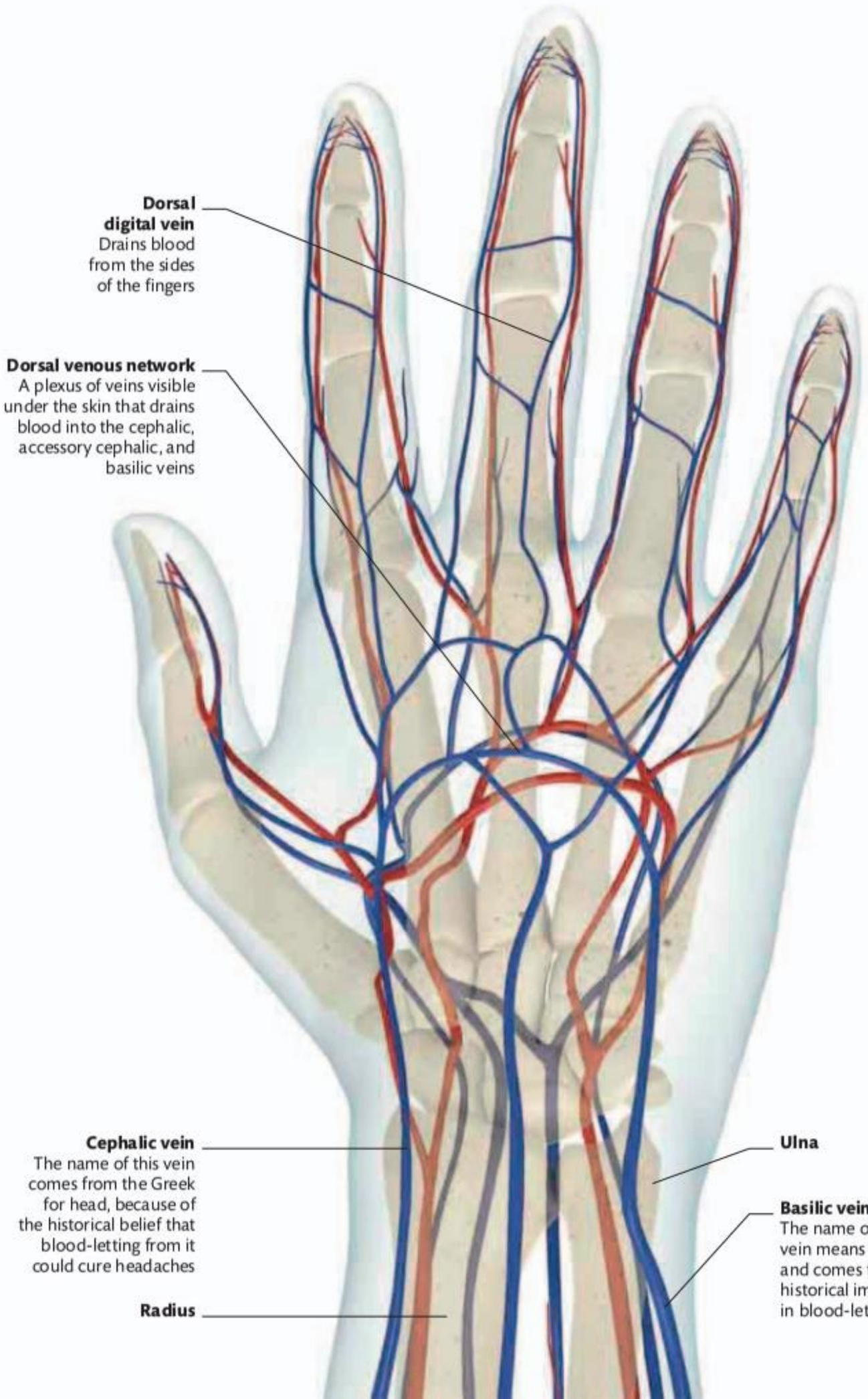


Dorsal digital vein
Drains blood from the sides of the fingers

Dorsal venous network
A plexus of veins visible under the skin that drains blood into the cephalic, accessory cephalic, and basilic veins

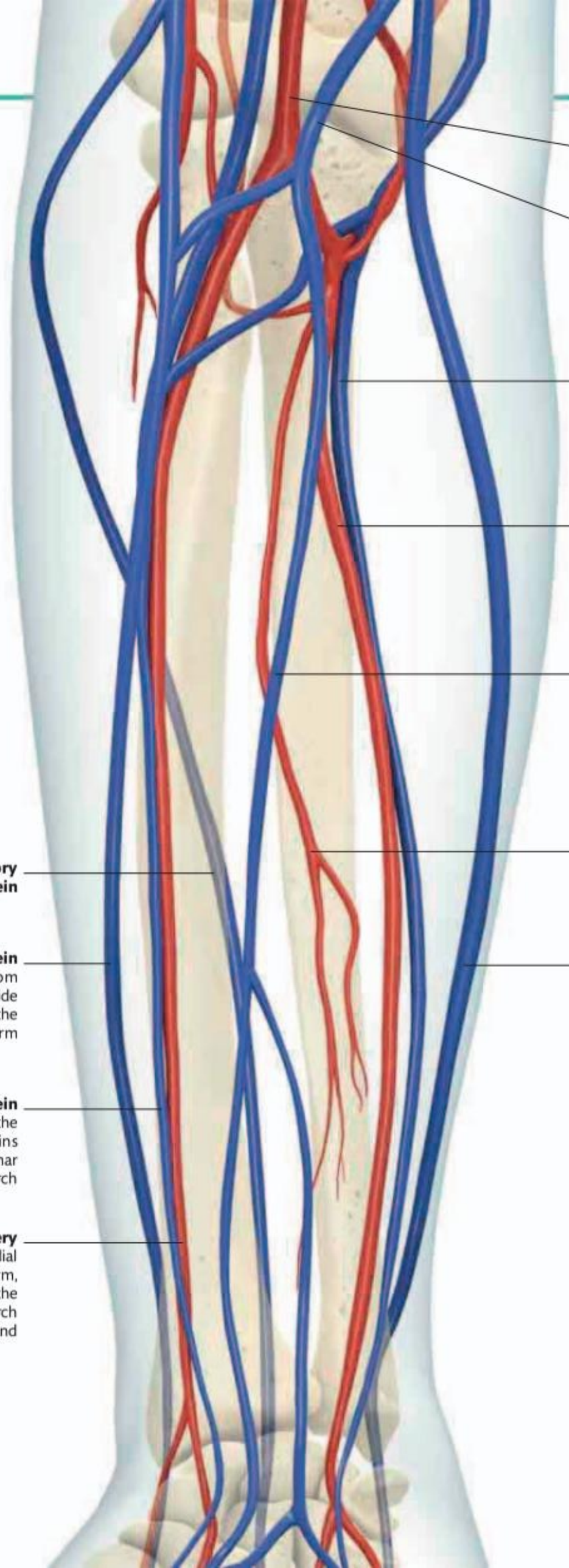
Cephalic vein
The name of this vein comes from the Greek for head, because of the historical belief that blood-letting from it could cure headaches

Radius

Ulna

Basilic vein
The name of this vein means royal and comes from its historical importance in blood-letting

ANTERIOR (FRONT)



Brachial artery

Median cubital vein
Connects the cephalic and basilic veins; is a preferred site for taking blood

Ulnar vein
Runs with the ulnar artery; drains the deep palmar venous arch

Ulnar artery
Supplies the ulnar side of the forearm; feeds into the superficial palmar arch

Median vein of the forearm
Drains the superficial venous plexus of the palm

Accessory cephalic vein

Cephalic vein
Drains blood from the radial side of the back of the hand and forearm

Radial vein
Runs with the radial artery; drains the superficial palmar venous arch

Radial artery
Supplies the radial side of the forearm, and feeds into the deep palmar arch of the hand

Interosseous artery

Basilic vein
Drains blood from the ulnar side of the back of the hand and forearm

LOWER ARM AND HAND

The brachial artery divides into two arteries, which take their names from the bones of the forearm: the radial and ulnar arteries. The radial artery can be felt at the wrist, and this is the most common place for taking a pulse as the strong pulsations are easy to feel when the artery is pressed against the bone beneath it. Furthermore, taking a pulse here doesn't even require any undressing. The radial and ulnar arteries end by joining up to form arterial arches in the wrist and palm. Digital arteries, destined for the fingers, spring off from the palmar arch. Superficial veins are concentrated on the back of the hand, rather than on the palm—otherwise those thin-walled vessels would be compressed every time a person gripped something. The dorsal venous network of the hand drains into two main vessels: the basilic and cephalic veins.

Deep palmar venous arch Drains blood from the fingers and palm into the radial and ulnar veins

Common palmar digital artery Carries blood toward the fingers

Palmar digital vein Drains the finger

Palmar digital artery Supplies the side of the finger

Deep palmar arch Links the radial and ulnar arteries and supplies the palm and fingers

Superfical palmar arch Links the radial and ulnar arteries and gives rise to the common palmar digital arteries

Superficial palmar venous arch Receives the palmar digial veins

Ulnar artery

Radial artery

Radial vein

Accessory cephalic vein One of the superficial veins draining blood from the back of the hand and forearm

POSTERIOR (BACK)

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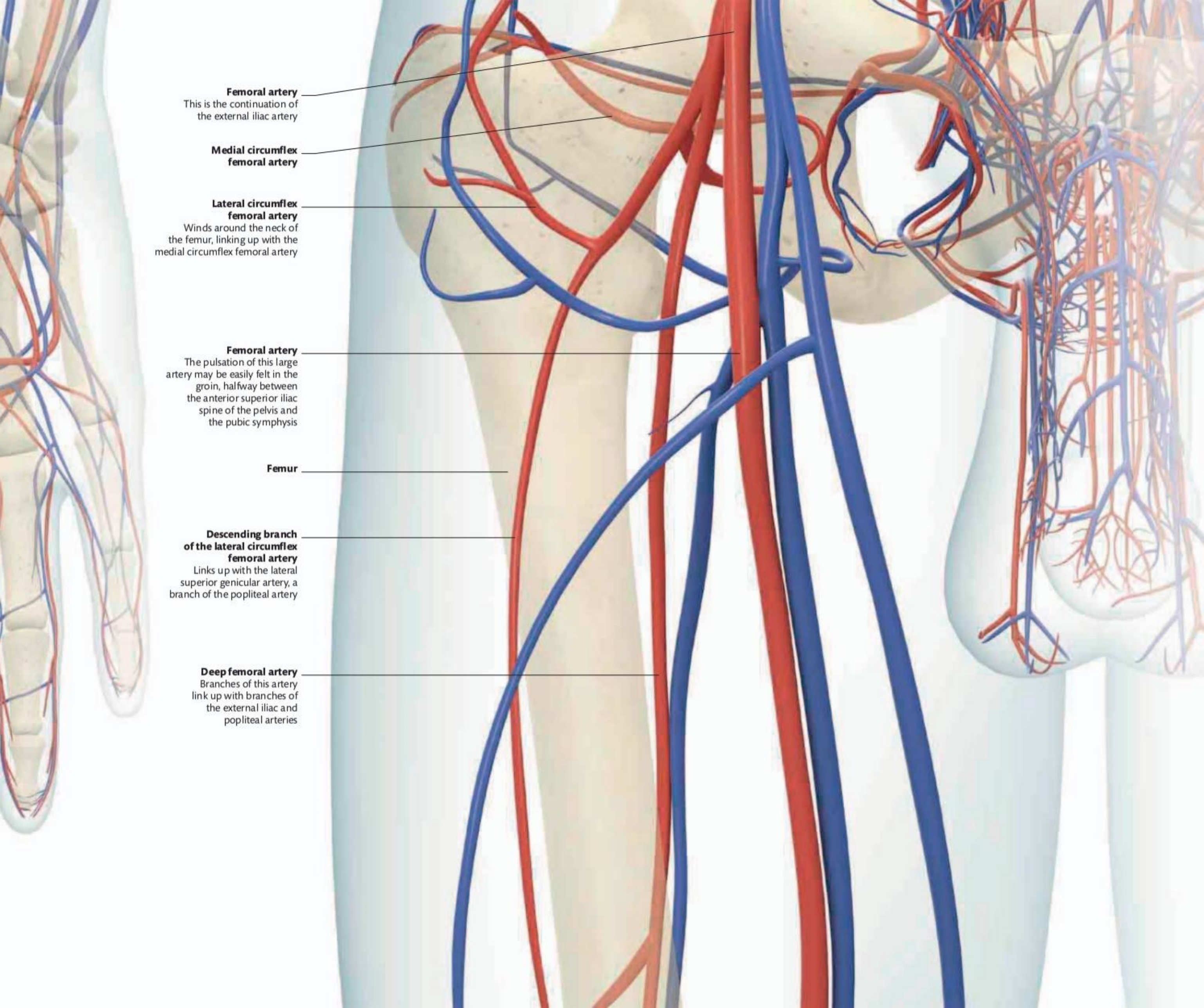
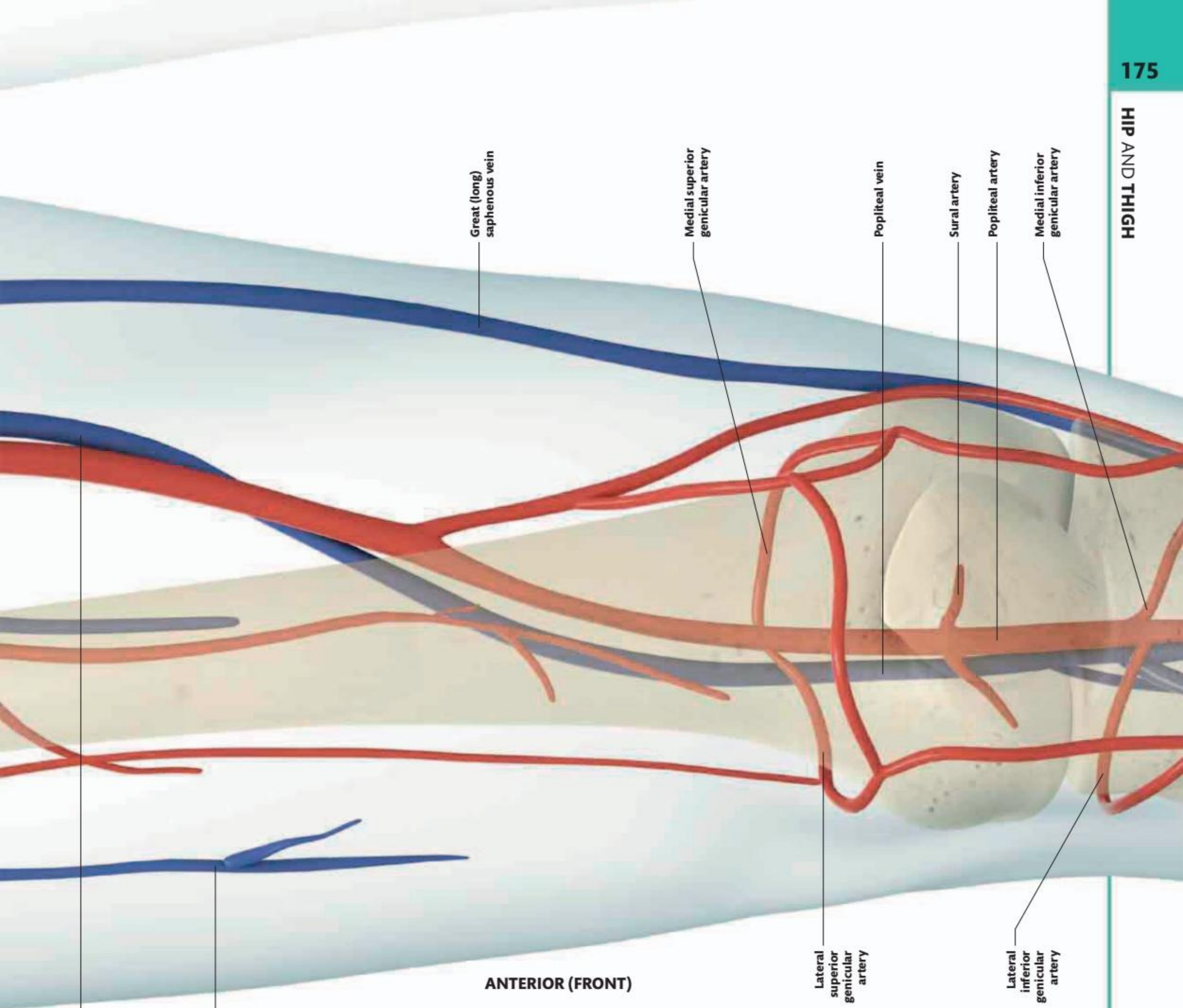

Femoral artery
This is the continuation of the external iliac artery
Medial circumflex femoral artery
Lateral circumflex femoral artery
Winds around the neck of the femur, linking up with the medial circumflex femoral artery
Femoral artery
The pulsation of this large artery may be easily felt in the groin, halfway between the anterior superior iliac spine of the pelvis and the pubic symphysis
Femur
Descending branch of the lateral circumflex femoral artery
Links up with the lateral superior genicular artery, a branch of the popliteal artery
Deep femoral artery
Branches of this artery link up with branches of the external iliac and popliteal arteries



HIP AND THIGH

As the external iliac artery runs over the pubic bone and underneath the inguinal ligament, it changes its name to the femoral artery—the main vessel carrying blood to the lower limb. The femoral artery lies exactly halfway along a line between the anterior superior iliac spine of the pelvis and the pubic symphysis. It has a large branch, the deep femoral artery, that supplies the muscles of the thigh. The femoral artery then runs toward the inner thigh, passing through the hole in the adductor magnus tendon, where its name changes to the popliteal artery. Deep veins run with the arteries, but—just as in the arm—there are also superficial veins. The great (or long) saphenous vein drains up the inner side of the leg and thigh, and ends by joining the femoral vein near the hip.

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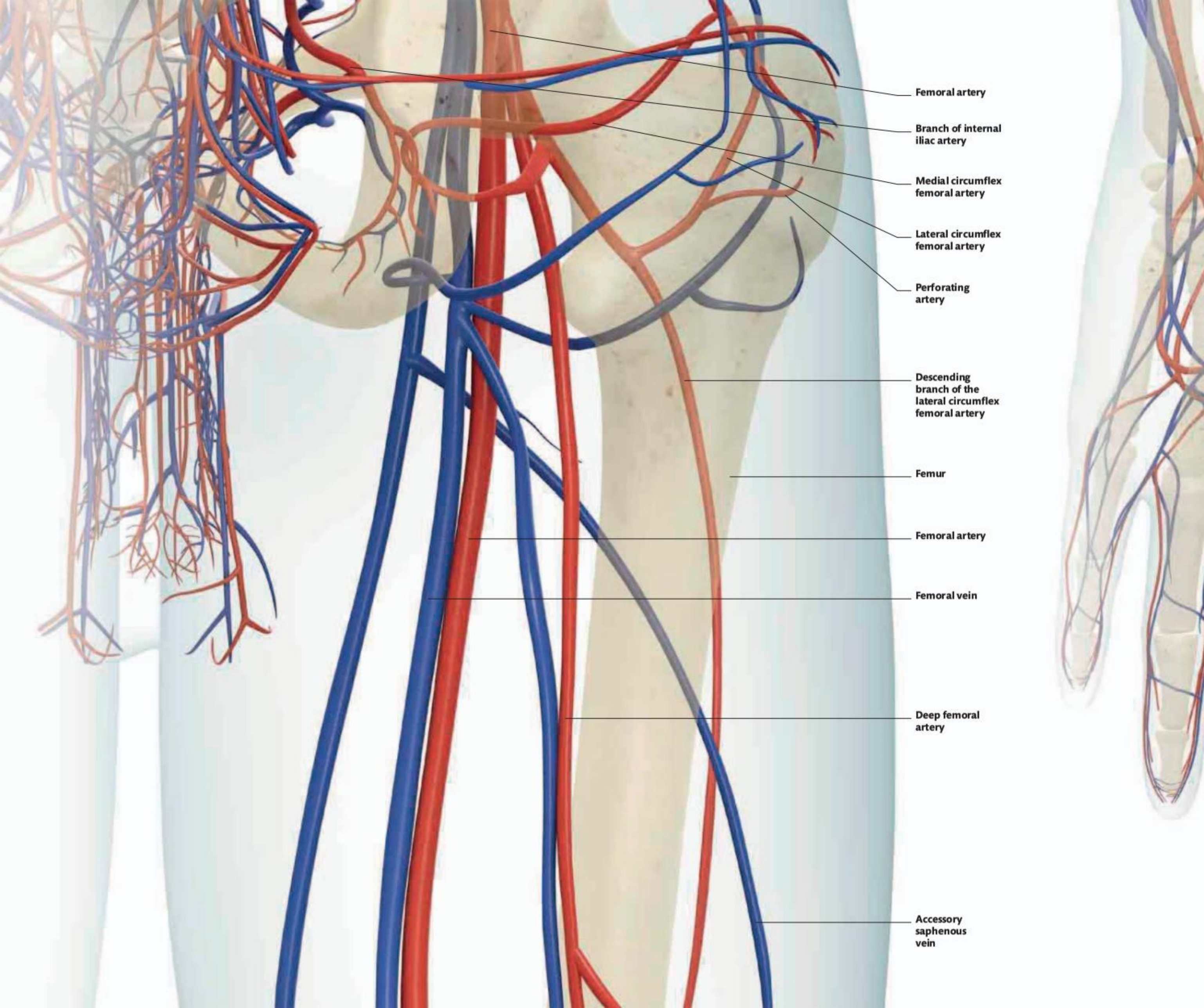
Femoral artery
Branch of internal iliac artery
Medial circumflex femoral artery
Lateral circumflex femoral artery
Perforating artery
Descending branch of the lateral circumflex femoral artery
Femur
Femoral artery
Femoral artery
Femoral vein
Deep femoral artery
Accessory saphenous vein

HIP AND THIGH

In this back view, gluteal branches of the internal iliac artery can be clearly seen, emerging through the greater sciatic foramen to supply the buttock. The muscles and skin of the inner part and back of the thigh are supplied by branches of the deep femoral artery. These are known as the perforating arteries because they pierce through the adductor magnus muscle. Higher up, the circumflex femoral arteries encircle the femur. The popliteal artery, formed after the femoral artery passes through the hiatus (gap) in adductor magnus, lies on the back of the femur, deep to the popliteal vein.

POSTERIOR (BACK)

Great (long) saphenous vein

Lateral superior genicular artery

Medial superior genicular artery

Popliteal artery
Lies deep in the popliteal fossa, at the back of the knee, where its pulse can be felt best with the knee flexed

Popliteal vein

Sural artery
Two sural arteries branch from the popliteal artery and supply the calf muscles

Lateral inferior genicular artery

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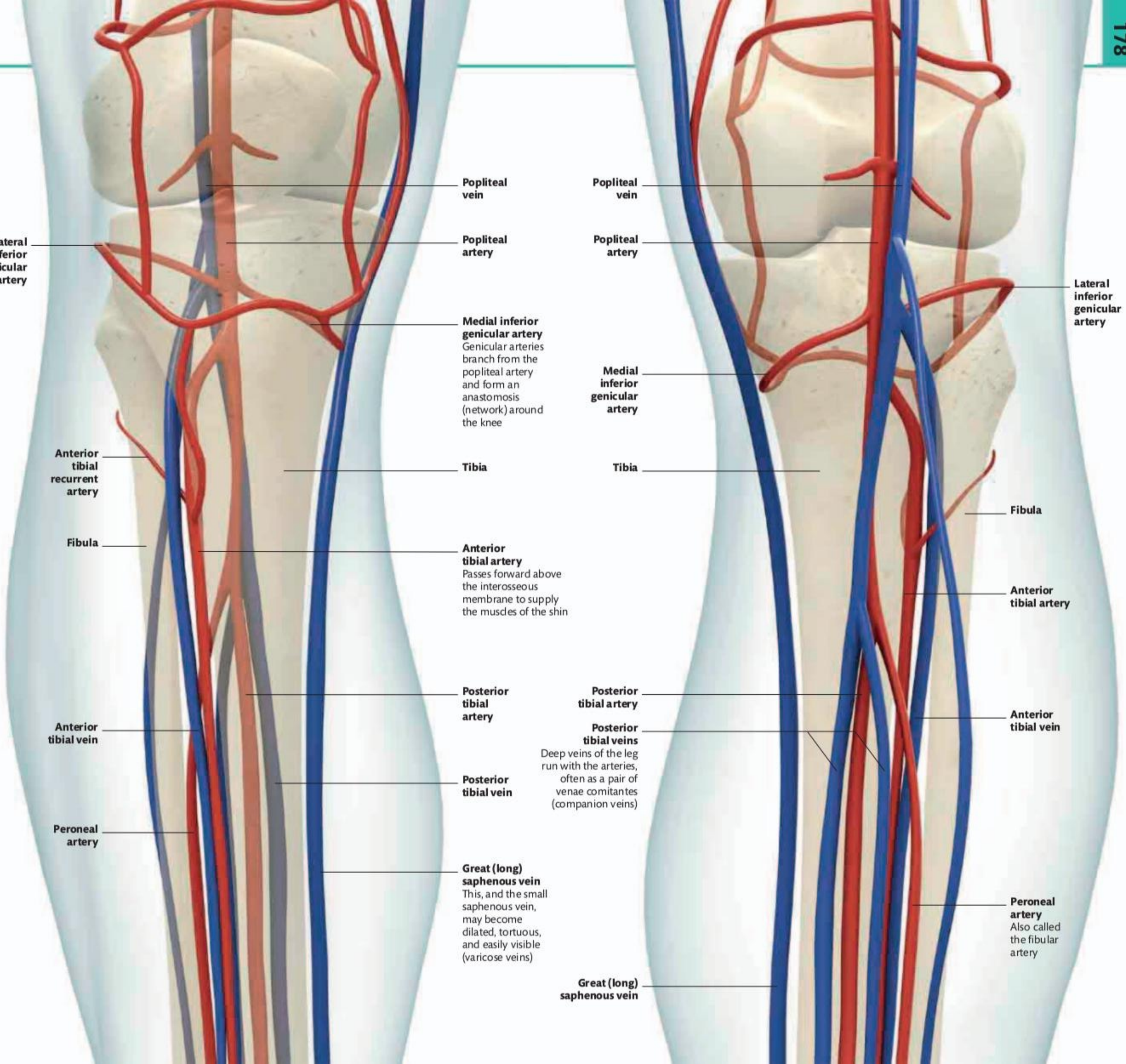
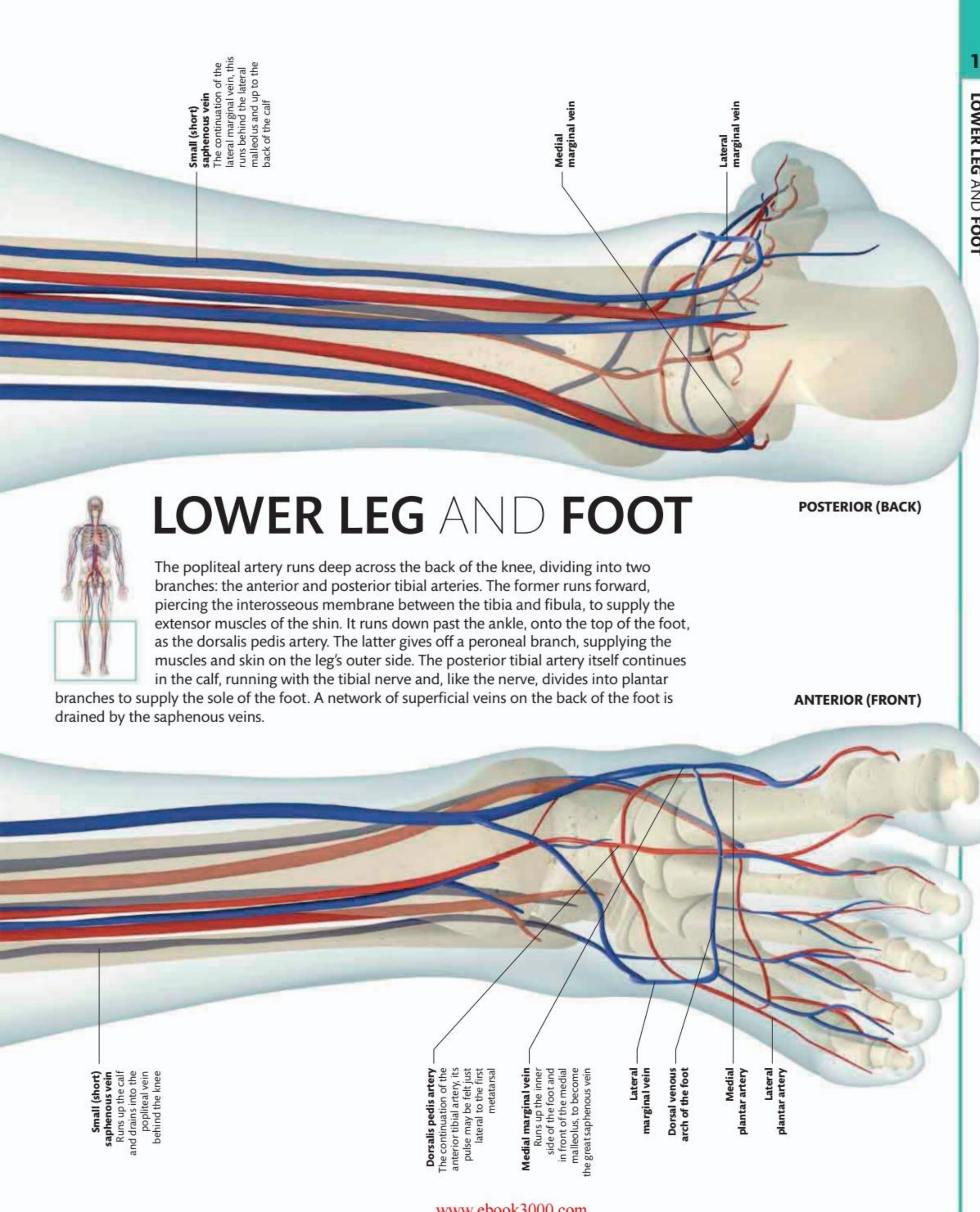

Popliteal vein
Lateral inferior genicular artery
Popliteal artery
Medial inferior genicular artery
Genicular arteries branch from the popliteal artery and form an anastomosis (network) around the knee
Anterior tibial recurrent artery
Tibia
Fibula
Anterior tibial artery
Passes forward above the interosseous membrane to supply the muscles of the shin
Posterior tibial artery
Anterior tibial vein
Posterior tibial vein
Peroneal artery
Great (long) saphenous vein
This, and the small saphenous vein, may become dilated, tortuous, and easily visible (varicose veins)
Popliteal vein
Popliteal artery
Lateral inferior genicular artery
Medial inferior genicular artery
Tibia
Fibula
Anterior tibial artery
Posterior tibial artery
Posterior tibial veins
Deep veins of the leg run with the arteries, often as a pair of venae comitantes (companion veins)
Anterior tibial vein
Peroneal artery
Also called the fibular artery
Great (long) saphenous vein



LOWER LEG AND FOOT

POSTERIOR (BACK)

The popliteal artery runs deep across the back of the knee, dividing into two branches: the anterior and posterior tibial arteries. The former runs forward, piercing the interosseous membrane between the tibia and fibula, to supply the extensor muscles of the shin. It runs down past the ankle, onto the top of the foot, as the dorsalis pedis artery. The latter gives off a peroneal branch, supplying the muscles and skin on the leg's outer side. The posterior tibial artery itself continues in the calf, running with the tibial nerve and, like the nerve, divides into plantar branches to supply the sole of the foot. A network of superficial veins on the back of the foot is drained by the saphenous veins.

ANTERIOR (FRONT)

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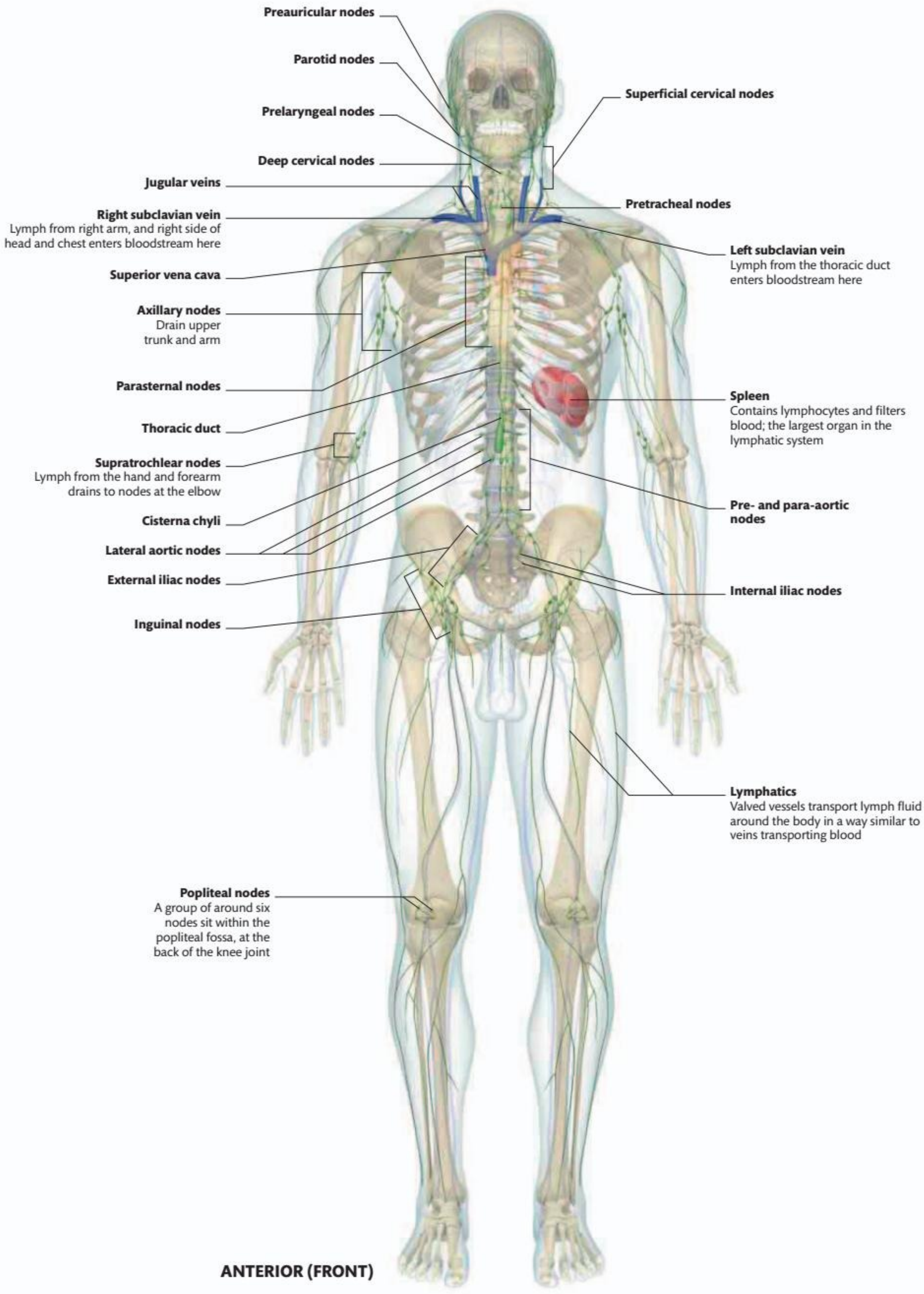
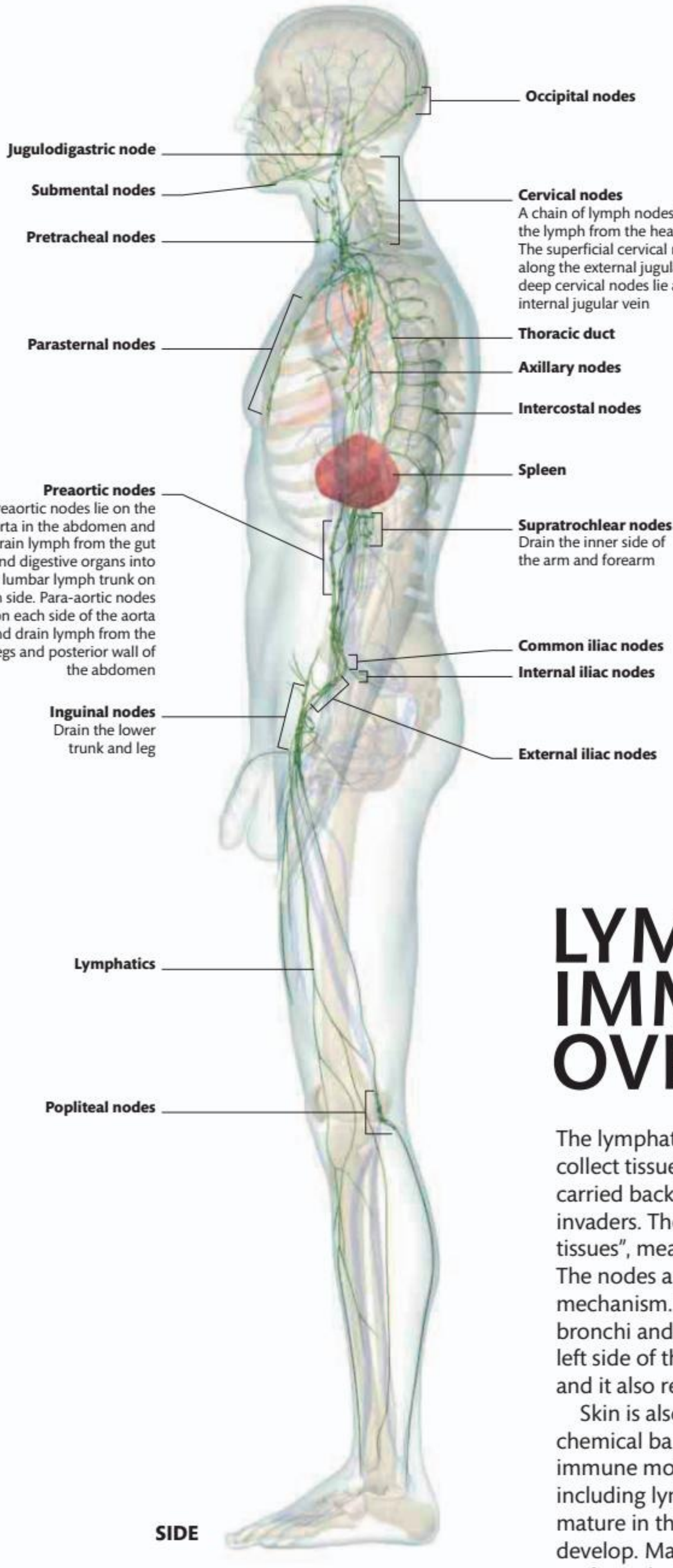
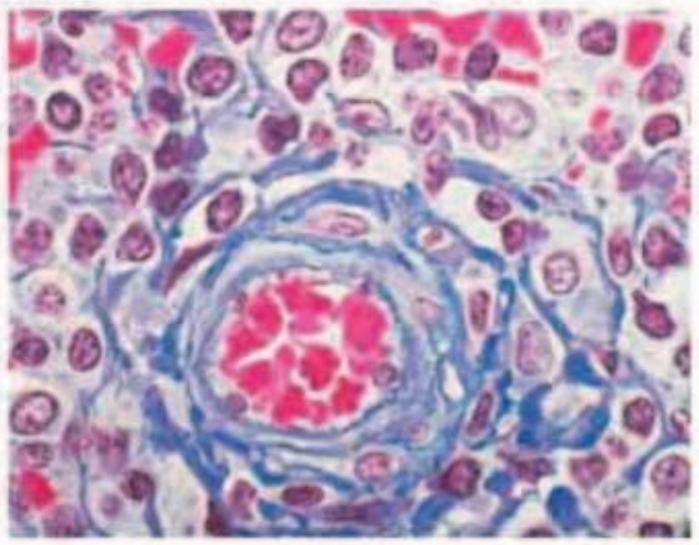
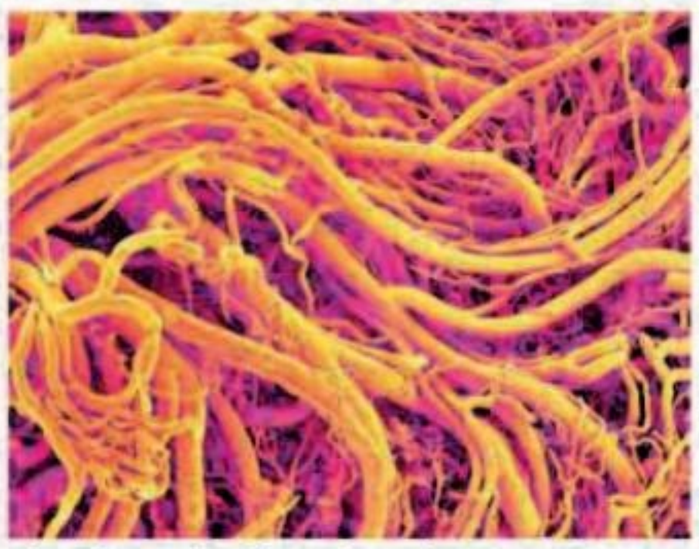

Preauricular nodes
Parotid nodes
Prelaryngeal nodes
Deep cervical nodes
Jugular veins
Right subclavian vein
Lymph from right arm, and right side of head and chest enters bloodstream here
Superior vena cava
Axillary nodes
Drain upper trunk and arm
Parasternal nodes
Thoracic duct
Supratrochlear nodes
Lymph from the hand and forearm drains to nodes at the elbow
Cisterna chyli
Lateral aortic nodes
External iliac nodes
Inguinal nodes
Popliteal nodes
A group of around six nodes sit within the popliteal fossa, at the back of the knee joint
Superficial cervical nodes
Pretracheal nodes
Left subclavian vein
Lymph from the thoracic duct enters bloodstream here
Spleen
Contains lymphocytes and filters blood; the largest organ in the lymphatic system
Pre- and para-aortic nodes
Internal iliac nodes
Lymphatics
Valved vessels transport lymph fluid around the body in a way similar to veins transporting blood
ANTERIOR (FRONT)





Lymphoid tissue
At a high magnification, individual lymphocytes (purple) can be seen in a section of lymphoid tissue. The blue circle in the image is an arteriole, packed full of blood cells (stained pink).



Blood vessels of lymph node
This image, produced using a scanning electron microscope, shows a resin cast of the dense network of tiny blood vessels inside a lymph node.

LYMPHATIC AND IMMUNE SYSTEM OVERVIEW

The lymphatic system consists of a network of lymphatic vessels that collect tissue fluid from the spaces between cells. Before this fluid is carried back to veins, it is delivered to lymph nodes to check for potential invaders. These nodes, like the tonsils, spleen, and thymus, are "lymphoid tissues", meaning that they contain immune cells known as lymphocytes. The nodes are therefore part of the immune system, the body's defense mechanism. There are also patches of lymphoid tissue in the walls of the bronchi and the gut. The spleen, which lies tucked under the ribs on the left side of the abdomen, has two important roles: it is a lymphoid organ, and it also removes old red blood cells from circulation.

Skin is also part of the immune system as it forms a physical and chemical barrier against infections. The formation of some important immune molecules, including antibodies, and a range of immune cells, including lymphocytes, happens in the bone marrow. Some lymphocytes mature in the bone marrow, whereas others move to the thymus to develop. Mature lymphocytes stay in the lymph nodes, where they perform their function.

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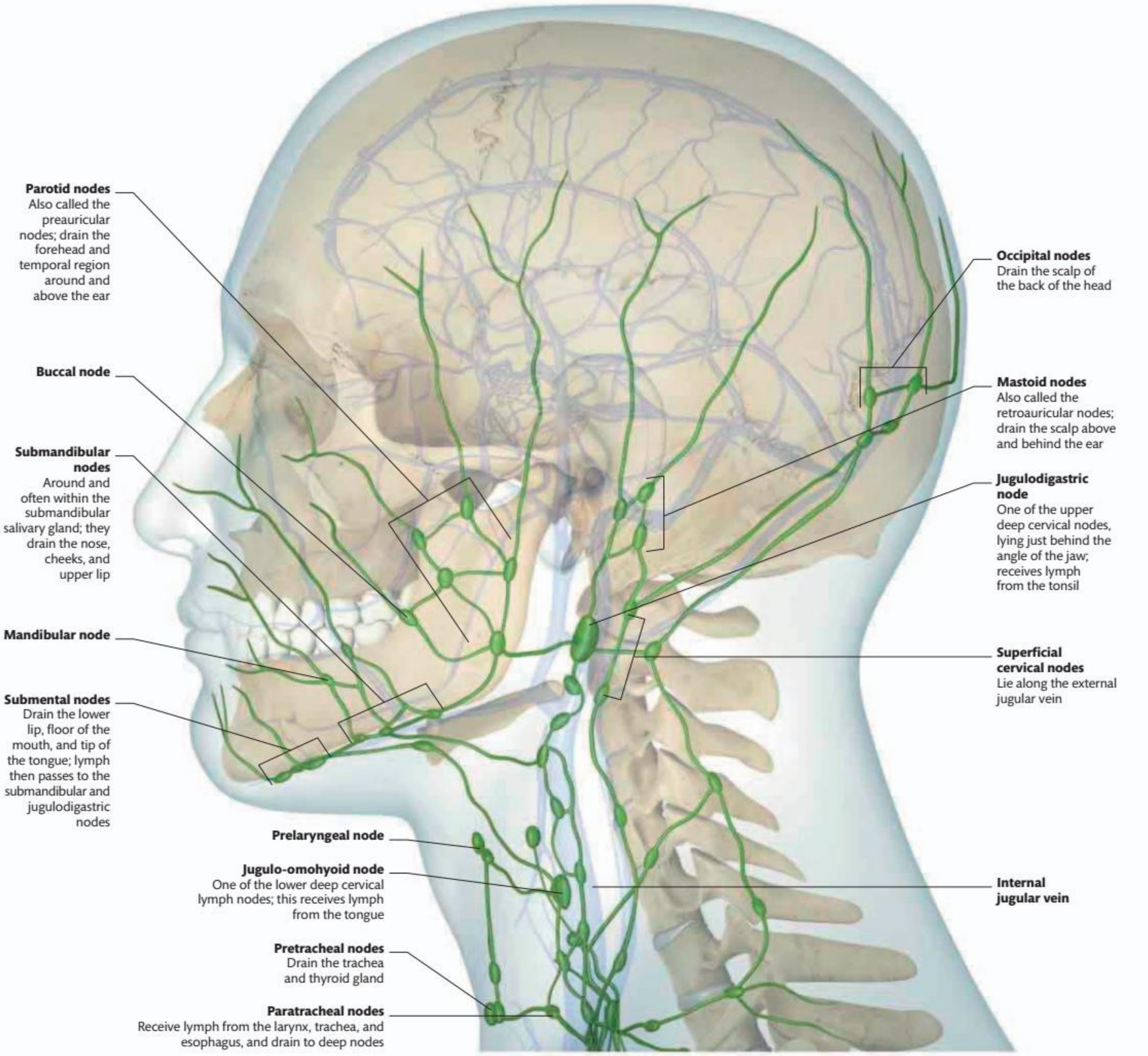
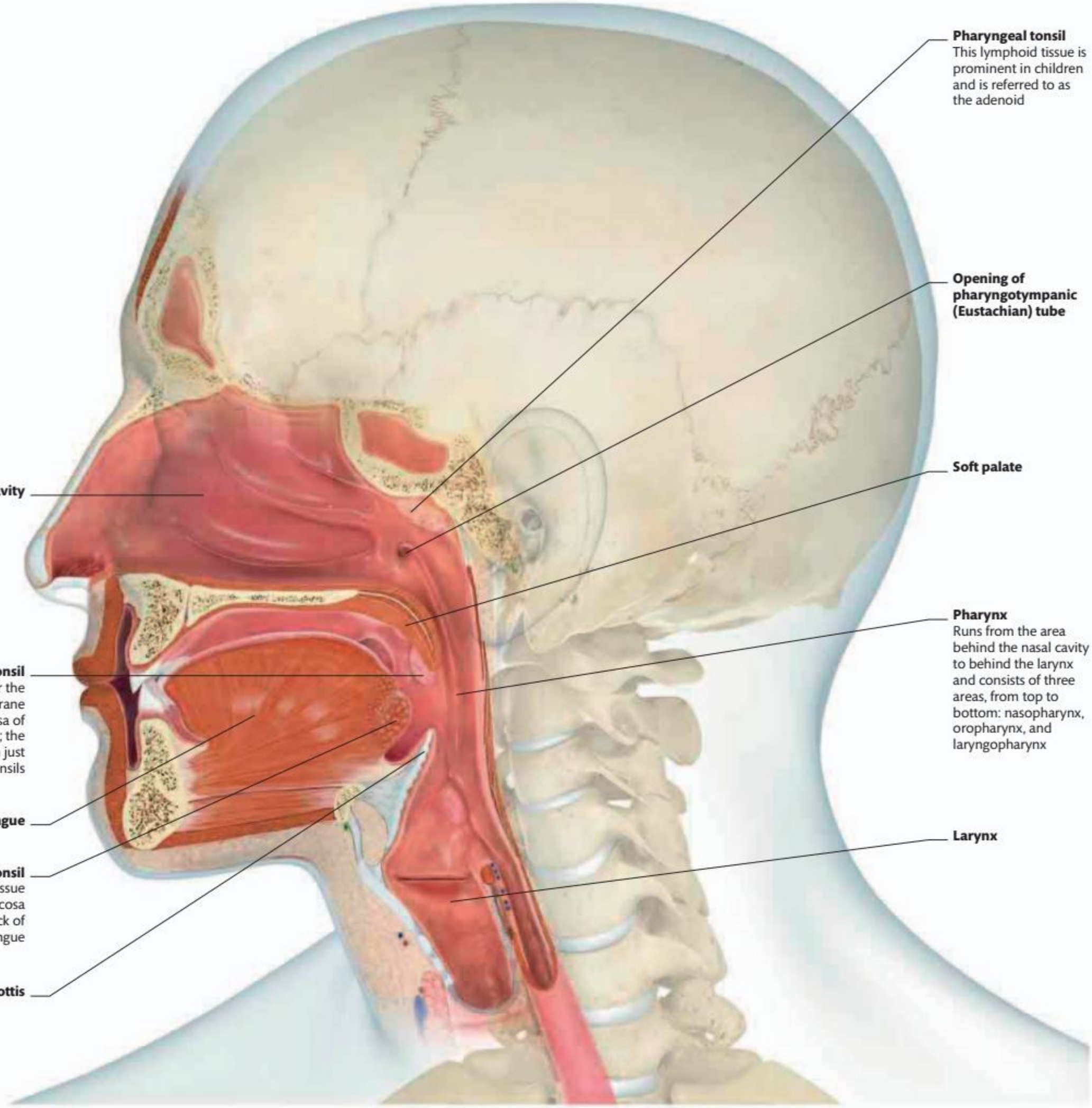


LYMPH NODES OF HEAD

HEAD AND NECK

A ring of lymph nodes lies close to the skin where the head meets the neck, from the occipital nodes (against the skull at the back) to the submandibular and submental nodes (which are tucked under the jaw). Superficial nodes lie along the sides and front of the neck, and deep nodes are clustered around the internal jugular vein, under cover of sternocleidomastoid muscle. Lymph from all other nodes passes to these deep ones, then into the jugular lymphatic trunk before draining back into veins in the base of the neck. Lymphoid tissue, in the form of the palatine, pharyngeal, and lingual tonsils, forms a protective ring around the upper parts of the respiratory and digestive tracts.



LOCATION OF TONSILS

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Right lymphatic duct
Lymph from the right arm and the right side of the neck and thorax drains into the junction of the right internal jugular and subclavian veins

Parasternal nodes
Also called internal thoracic nodes; these lie in the gaps between the ribs, either side of the sternum on the inside of the ribcage; they drain some of the lymph from the front of the thorax – including from the breast in a woman

Axillary nodes
Receive lymph from superficial tissues of the thorax, upper limb, and breast

Intercostal nodes
Sitting in the intercostal spaces between the ribs at the back of the ribcage, these drain lymph from the deeper tissues at the sides and back of the thorax

ANTERIOR (FRONT) / FEMALE

ANTERIOR (FRONT) / MALE

Thymus
Immune-system organ where the lymphocytes mature and become T cells; its function and size decrease after puberty

THYMUS IN CHILD

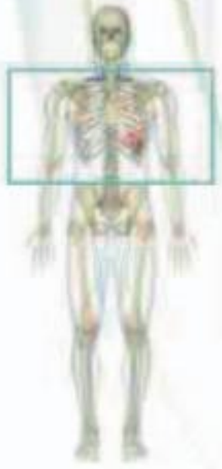
Termination of thoracic duct
The thoracic duct ends by draining into the point where the left internal jugular and subclavian veins join at the bottom of the neck

Tracheobronchial nodes
Clustered around the lower trachea and bronchi, these nodes drain the lungs

Posterior mediastinal node
Tucked behind the heart, these receive lymph from the heart, esophagus, and diaphragm

Thoracic duct
Lies right at the back of the thorax, against the spine

THORAX



Most of the tissue fluid, or lymph, from the superficial tissues of the chest drains to axillary nodes, high in the armpits. The complex drainage of the female breast passes to these and to the parasternal, supraclavicular, and abdominal nodes. Lymph from deeper tissues drains to nodes in the thorax, some nestled between the ribs or on the diaphragm, others tucked behind the heart or grouped around the bronchi and trachea. Tissue fluid from the thorax's left side ultimately drains into the thoracic duct, a large lymphatic vessel at the back of the thorax. Fluid from the right side drains into the right lymphatic duct. Both ducts empty into veins at the base of the neck. The thymus, a vital immune-system organ that lies behind the sternum, is largest during childhood. T lymphocytes mature in the thymus before leaving to populate lymph nodes.

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ABDOMEN AND PELVIS

The deep lymph nodes of the abdomen are clustered around arteries. Nodes lying along each side of the aorta receive lymph from paired structures, such as the muscles of the abdominal wall, the kidneys and adrenal glands, and the testes or ovaries. Iliac nodes collect lymph returning from the legs and pelvis. Nodes clustered around the branches on the front of the aorta collect lymph from the gut and abdominal organs. Eventually, all this lymph from the legs, pelvis, and abdomen passes into a swollen lymphatic vessel called the cisterna chyli; this narrows down to become the thoracic duct, which runs up into the chest. Most lymph nodes are small, bean-sized structures, but the abdomen also contains a large and important organ of the immune system—the spleen.

Lateral aortic nodes
Lying along each side of the aorta, these collect lymph from the kidneys, posterior abdominal wall, and pelvic viscera; they drain into the right and left intestinal trunks

External iliac nodes
Collect lymph from the inguinal nodes in the groin, from the perineum, and the inner thigh

Proximal superficial inguinal nodes
Lying just below the inguinal ligament, this upper group of superficial inguinal nodes receives lymph from the lower abdominal wall, below the umbilicus, as well as from the external genitalia

Distal superficial inguinal nodes
The lower nodes in the groin drain most of the superficial lymphatics of the thigh and leg

Thoracic duct

Spleen
Contains red pulp, into which old, tired red blood cells are removed from circulation, and also white pulp, which is full of lymphocytes, making it much like a massive lymph node

Celiac nodes
Drain lymph from the organs supplied by the celiac artery, including the liver, pancreas, and stomach

Cisterna chyli
Formed by the confluence of the main lymph trunks—the lumbar and intestinal trunks—in the abdomen. This leads into the thoracic duct. In Greek, the name means juice reservoir

Mesenteric nodes
Nestled around the origins of the superior and inferior mesenteric arteries from the aorta, these drain most of the lymph from the intestines

Common iliac nodes
Receive lymph from the external and internal iliac nodes and drain up to the lateral aortic nodes

Internal iliac nodes
Drain lymph from the organs of the pelvis

ANTERIOR (FRONT)

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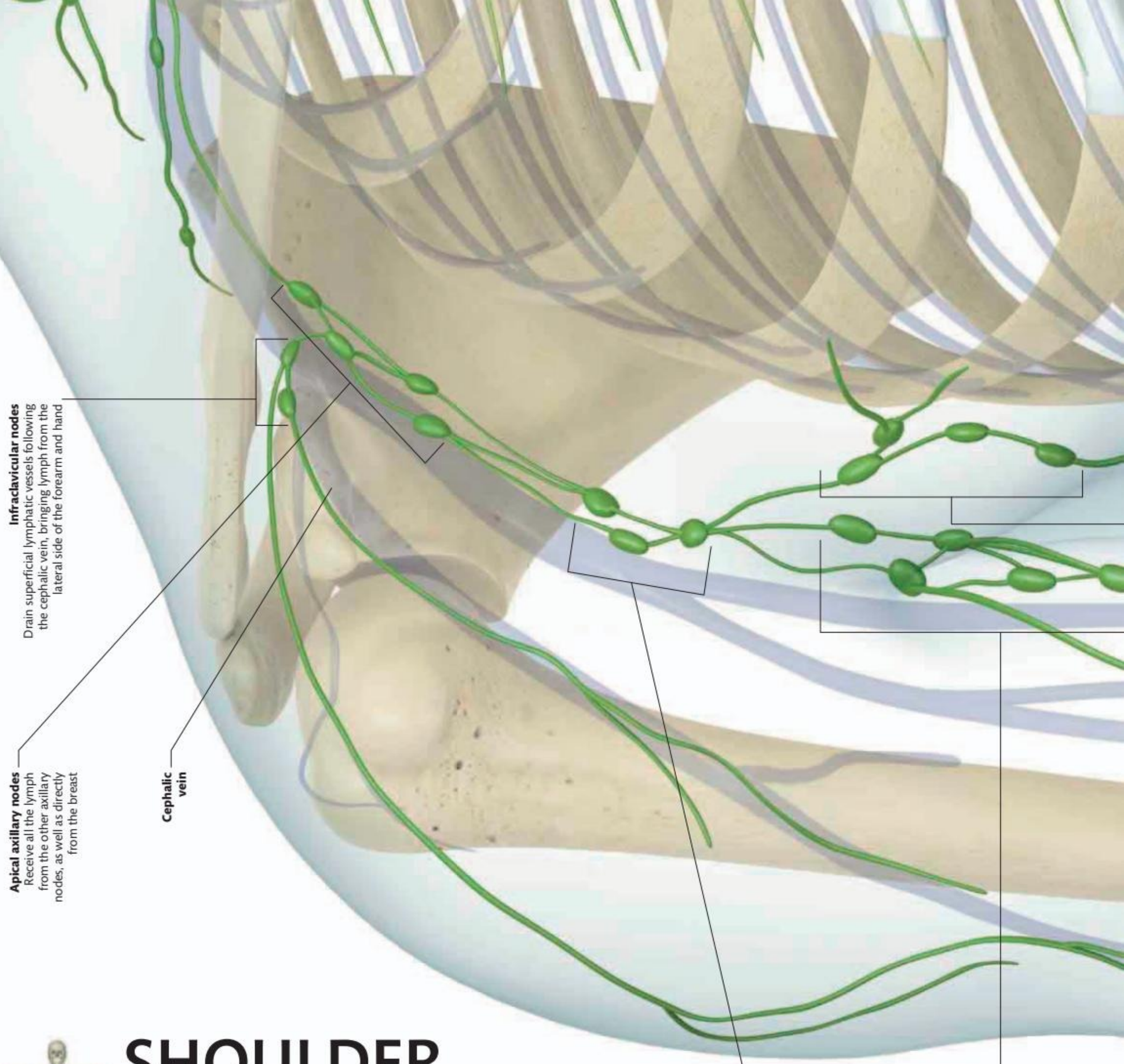

SHOULDER AND UPPER ARM

Ultimately, all the lymph from the hand, forearm, and arm drains to the axillary nodes in the armpit. But there are a few nodes, lower in the arm, that lymph may pass through on its way to the axilla. The supratrochlear nodes lie in the subcutaneous fat on the inner arm, above the elbow. They collect lymph that has drained from the medial side of the hand and forearm. The infraclavicular nodes, lying along the cephalic vein, below the clavicle, receive lymphatics draining from the thumb and the lateral side of the forearm and arm. Axillary nodes drain lymph from the arm and receive it from the chest wall. They may become infiltrated with cancerous cells spreading from a tumor in the breast.

Anterior axillary nodes
Drain lymph from the trunk above the umbilicus, including the front of the chest and breast

Supratrochlear nodes
Drain superficial tissues on the inner (medial) side of the hand and forearm

ANTERIOR (FRONT)

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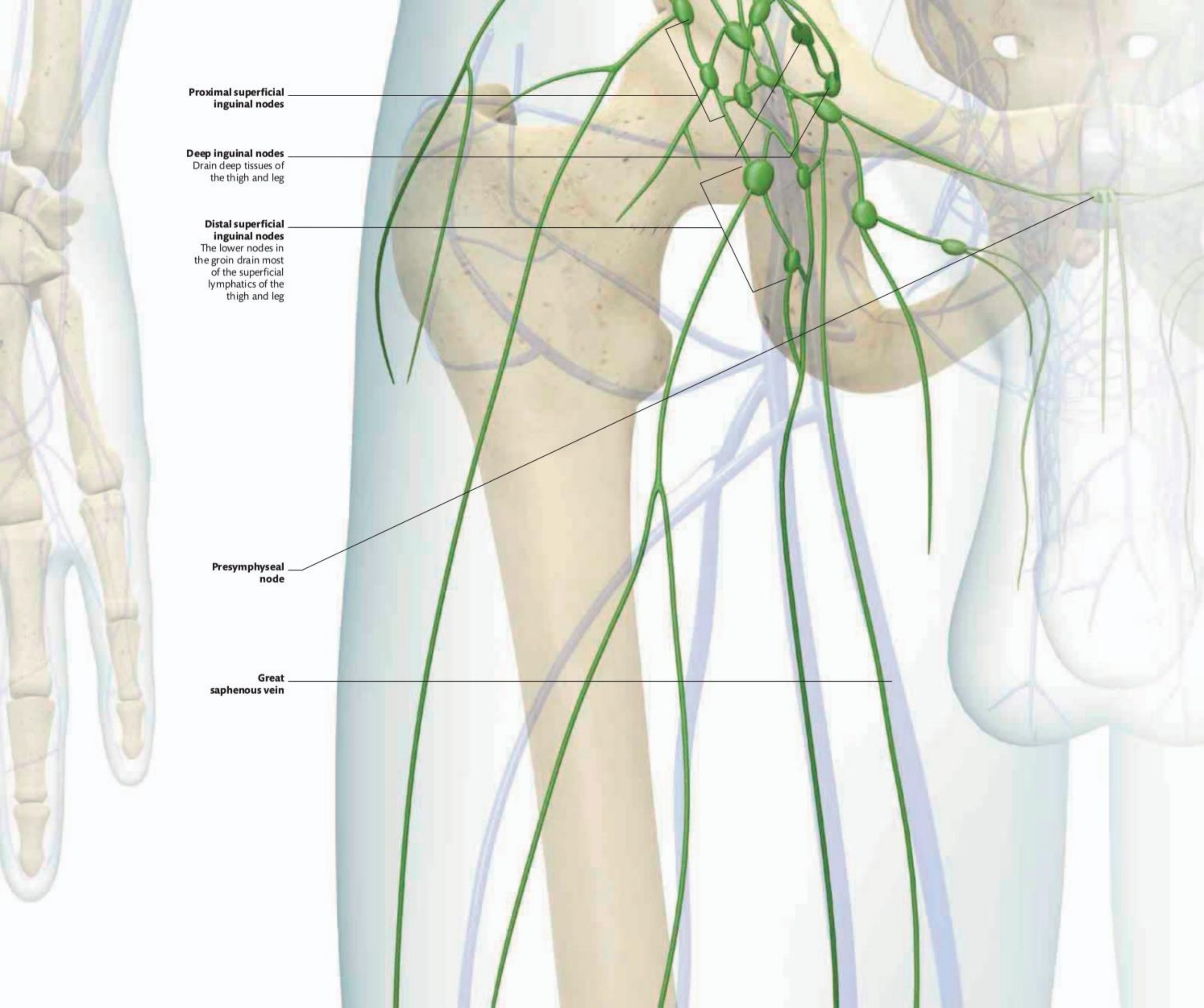
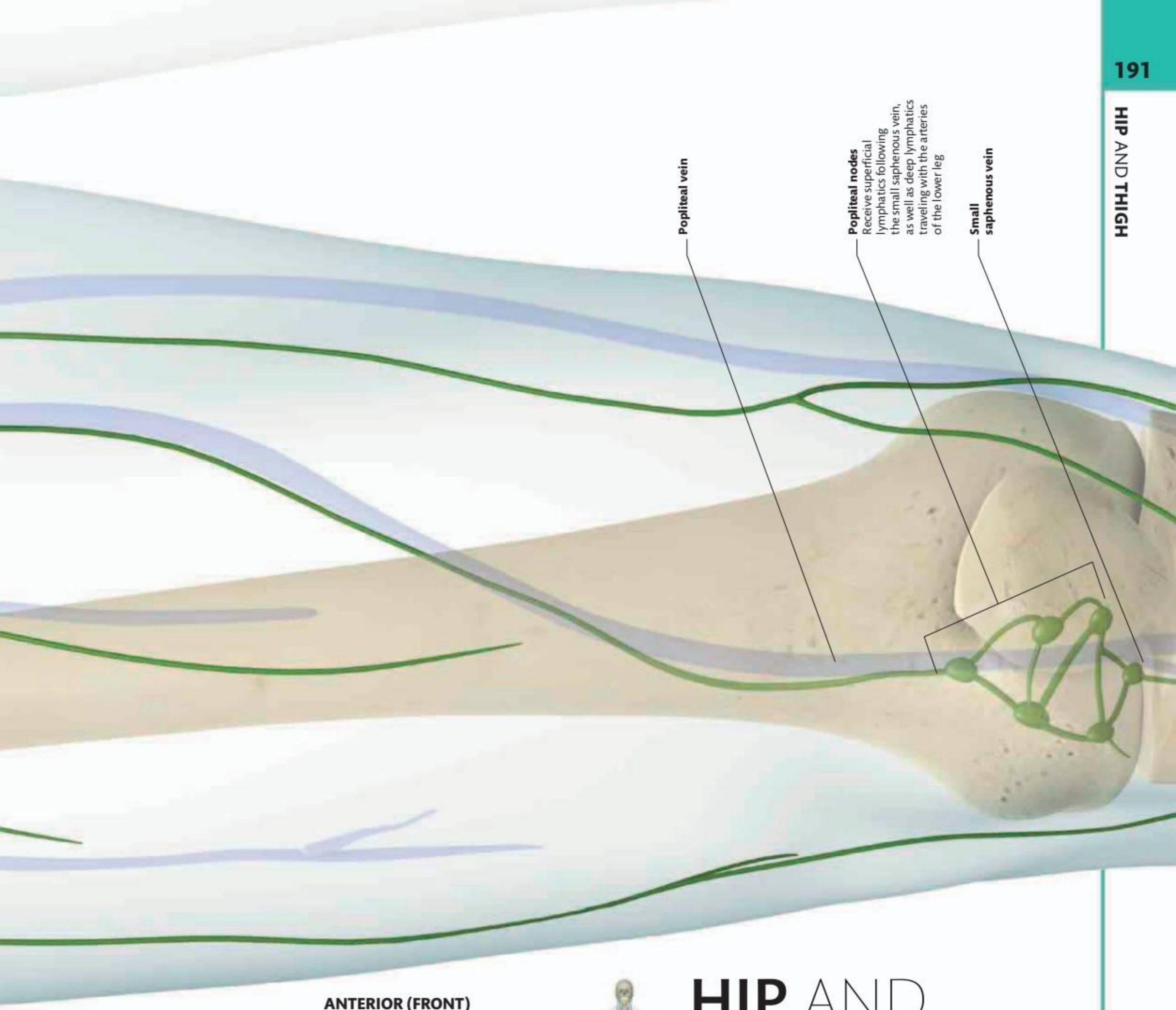

Proximal superficial inguinal nodes
Deep inguinal nodes
Drain deep tissues of the thigh and leg
Distal superficial inguinal nodes
The lower nodes in the groin drain most of the superficial lymphatics of the thigh and leg
Presymphyseal node
Great saphenous vein



HIP AND THIGH

Most lymph from the thigh, leg, and foot passes through the inguinal group of lymph nodes, which are in the groin. But lymph from the deep tissues of the buttock passes straight to nodes inside the pelvis (see pp.184–85), along the internal and common iliac arteries. Eventually, all the lymph from the leg reaches the lateral aortic nodes, on the back wall of the abdomen. As in the arm, there are groups of nodes clustered around points at which superficial veins drain into deep veins. Popliteal nodes are close to the drainage of the small saphenous vein into the popliteal vein, while the superficial inguinal nodes lie close to the great saphenous vein, just before it empties into the femoral vein.

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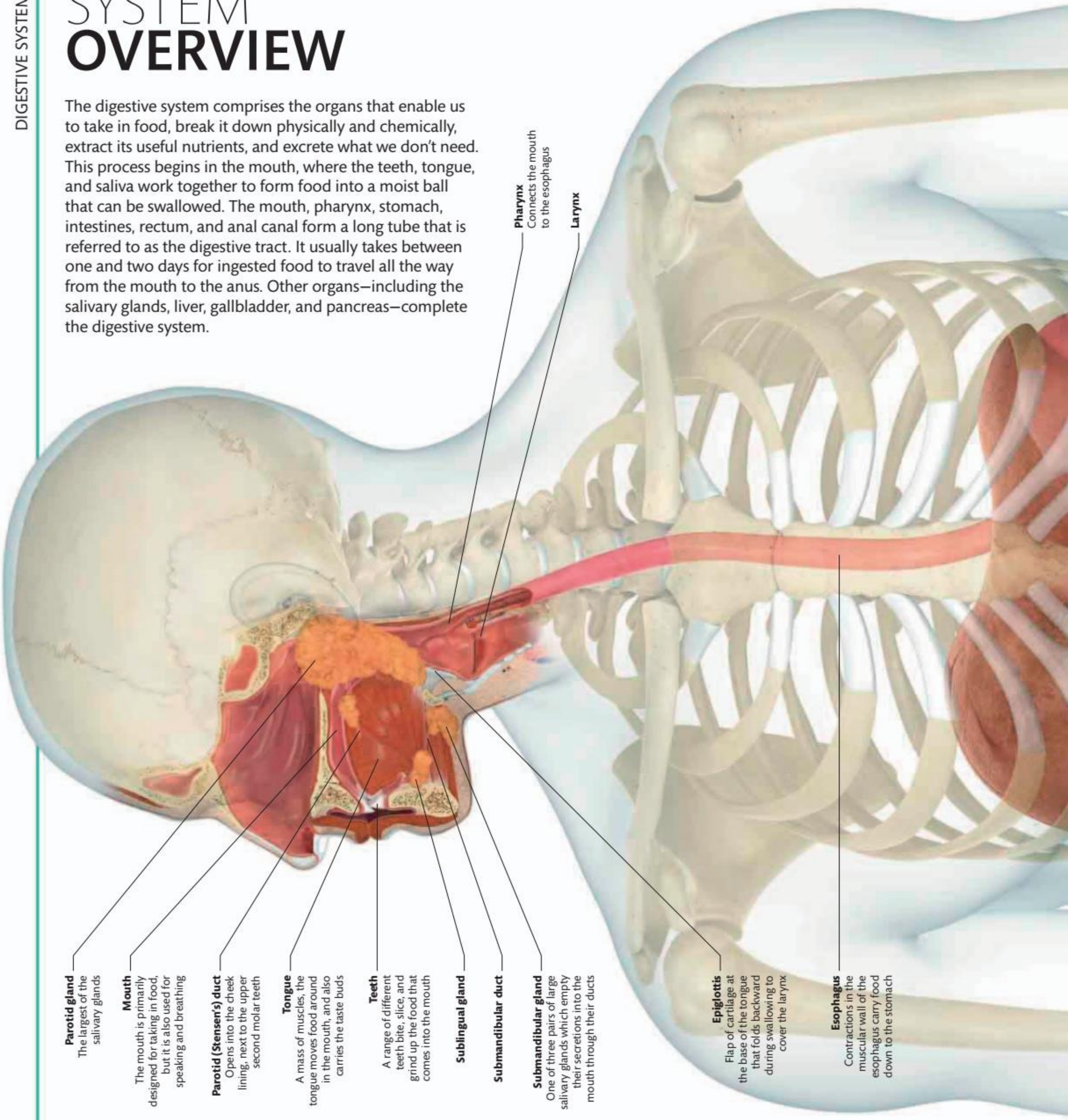
DIGESTIVE SYSTEM **OVERVIEW**

The digestive system comprises the organs that enable us to take in food, break it down physically and chemically, extract its useful nutrients, and excrete what we don't need. This process begins in the mouth, where the teeth, tongue, and saliva work together to form food into a moist ball that can be swallowed. The mouth, pharynx, stomach, intestines, rectum, and anal canal form a long tube that is referred to as the digestive tract. It usually takes between one and two days for ingested food to travel all the way from the mouth to the anus. Other organs—including the salivary glands, liver, gallbladder, and pancreas—complete the digestive system.



Pharynx
Connects the mouth to the esophagus

Larynx

Parotid gland
The largest of the salivary glands

Mouth
The mouth is primarily designed for taking in food, but it is also used for speaking and breathing

Parotid (Stensen's) duct
Opens into the cheek lining, next to the upper second molar teeth

Tongue
A mass of muscles, the tongue moves food around in the mouth, and also carries the taste buds

Teeth
A range of different teeth bite, slice, and grind up the food that comes into the mouth

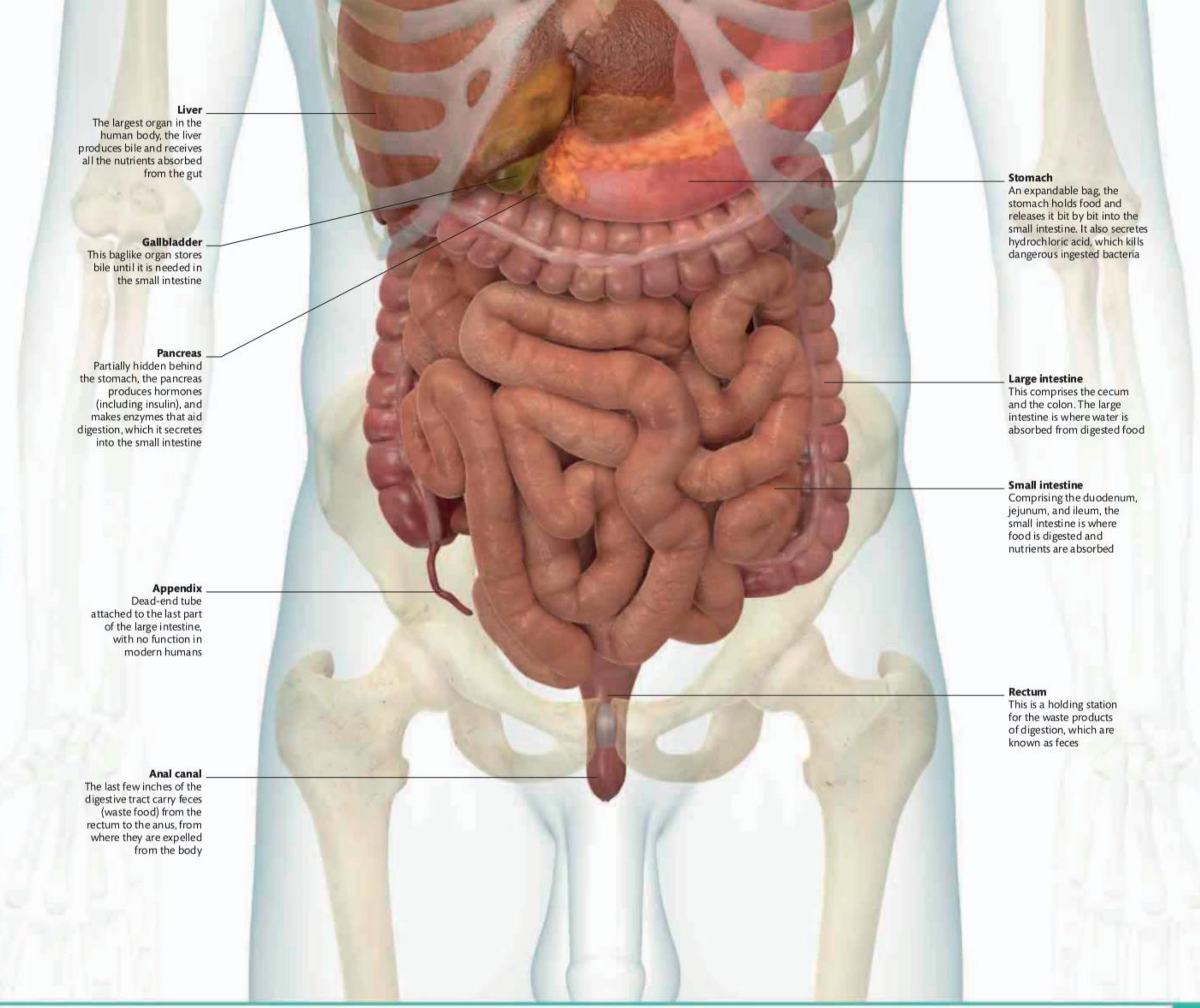
Sublingual gland

Submandibular duct

Submandibular gland
One of three pairs of large salivary glands which empty their secretions into the mouth through their ducts

Epiglottis
Flap of cartilage at the base of the tongue that folds backward during swallowing to cover the larynx

Esophagus
Contractions in the muscular wall of the esophagus carry food down to the stomach



Liver
The largest organ in the human body, the liver produces bile and receives all the nutrients absorbed from the gut

Gallbladder
This baglike organ stores bile until it is needed in the small intestine

Pancreas
Partially hidden behind the stomach, the pancreas produces hormones (including insulin), and makes enzymes that aid digestion, which it secretes into the small intestine

Appendix
Dead-end tube attached to the last part of the large intestine, with no function in modern humans

Anal canal
The last few inches of the digestive tract carry feces (waste food) from the rectum to the anus, from where they are expelled from the body

Stomach
An expandable bag, the stomach holds food and releases it bit by bit into the small intestine. It also secretes hydrochloric acid, which kills dangerous ingested bacteria

Large intestine
This comprises the cecum and the colon. The large intestine is where water is absorbed from digested food

Small intestine
Comprising the duodenum, jejunum, and ileum, the small intestine is where food is digested and nutrients are absorbed

Rectum
This is a holding station for the waste products of digestion, which are known as feces

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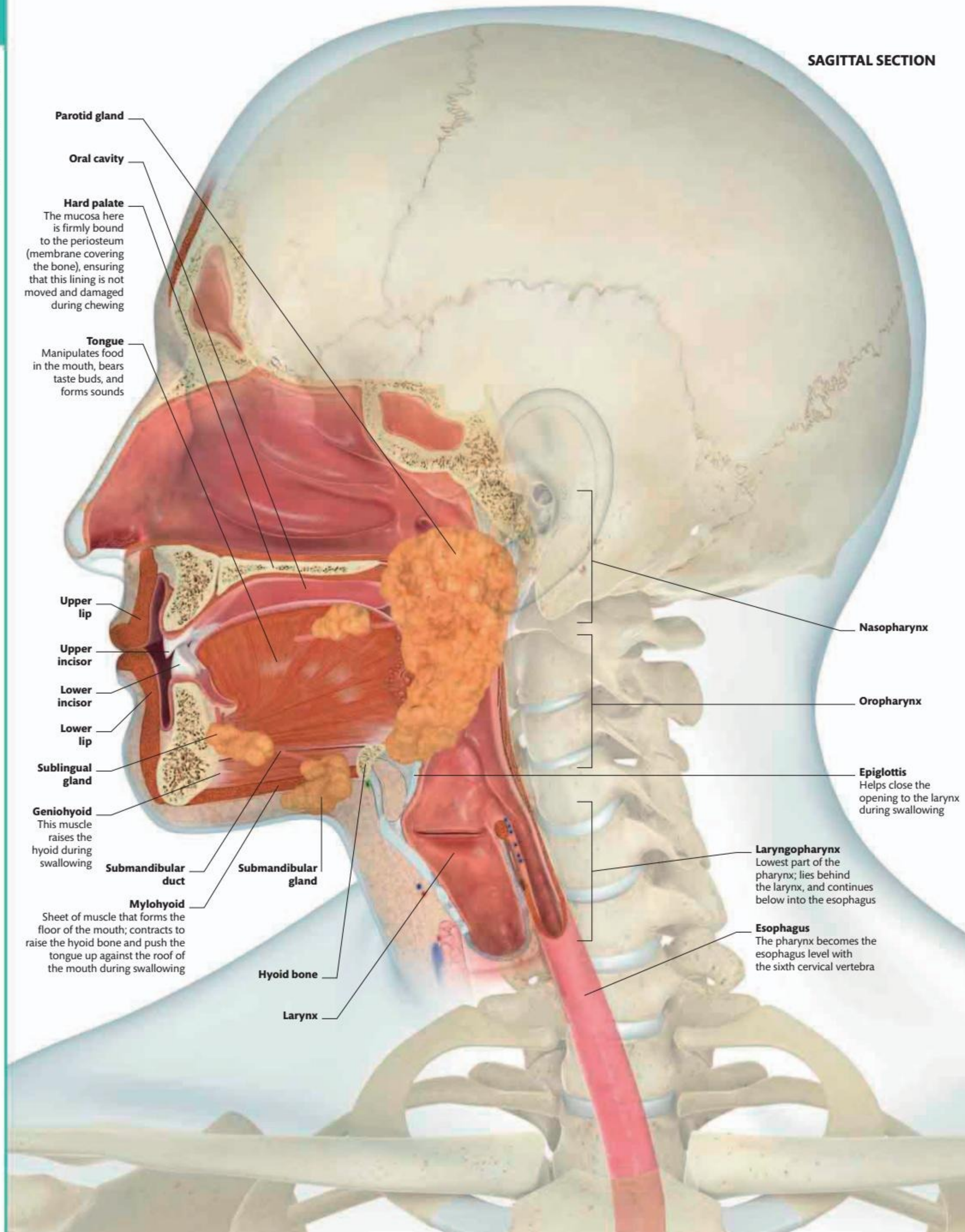
SAGITTAL SECTION



Parotid gland

Oral cavity

Hard palate
The mucosa here is firmly bound to the periosteum (membrane covering the bone), ensuring that this lining is not moved and damaged during chewing

Tongue
Manipulates food in the mouth, bears taste buds, and forms sounds

Upper lip

Upper incisor

Lower incisor

Lower lip

Sublingual gland

Geniohyoid
This muscle raises the hyoid during swallowing

Submandibular duct

Submandibular gland

Mylohyoid
Sheet of muscle that forms the floor of the mouth; contracts to raise the hyoid bone and push the tongue up against the roof of the mouth during swallowing

Hyoid bone

Larynx

Nasopharynx

Oropharynx

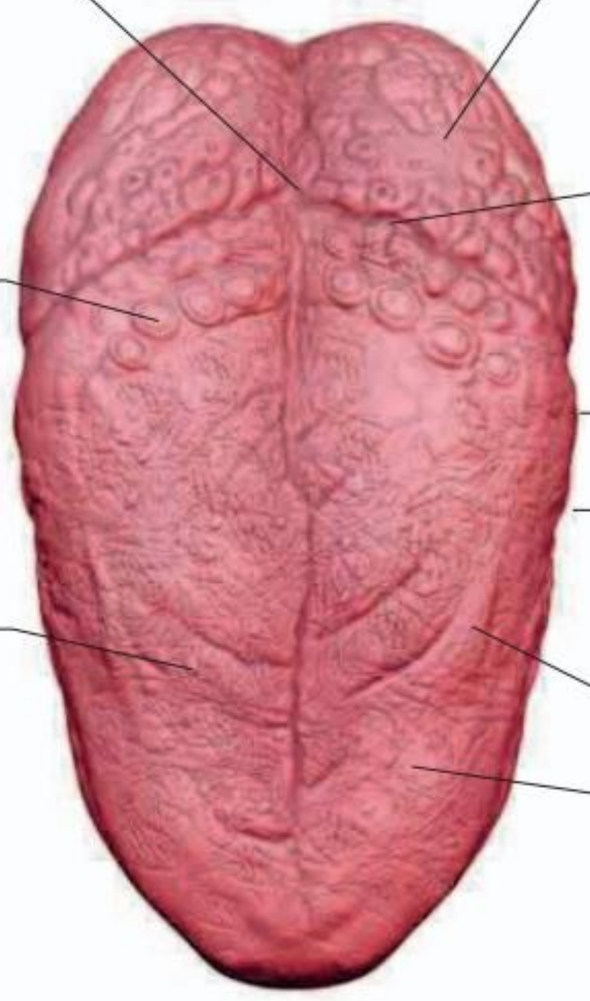
Epiglottis
Helps close the opening to the larynx during swallowing

Laryngopharynx
Lowest part of the pharynx; lies behind the larynx, and continues below into the esophagus

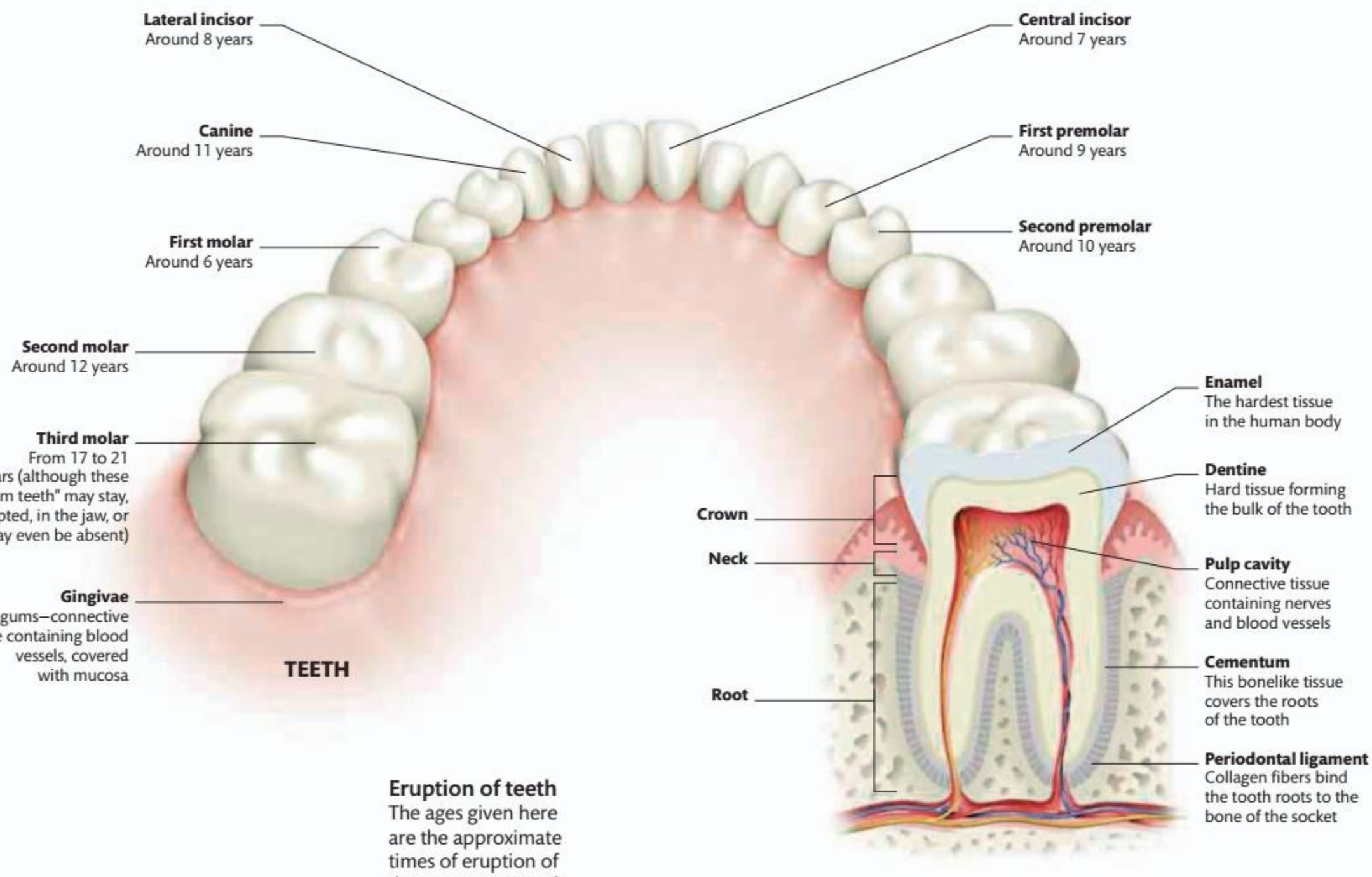
Esophagus
The pharynx becomes the esophagus level with the sixth cervical vertebra

HEAD AND NECK

The mouth is the first part of the digestive tract, and it is here that the processes of mechanical and chemical digestion get underway. Your teeth grind each mouthful, and you have three pairs of major salivary glands—parotid, submandibular, and sublingual—that secrete saliva through ducts into the mouth. Saliva contains digestive enzymes that begin to chemically break down the food in your mouth. The tongue manipulates the food, and also has taste buds that allow you to quickly make the important distinction between delicious food and potentially harmful toxins. As you swallow, the tongue pushes up against the hard palate, the soft palate seals off the airway, and the muscular tube of the pharynx contracts in a wave to push the ball of food down into the esophagus, ready for the next stage of its journey.



TONGUE



TEETH

Eruption of teeth
The ages given here are the approximate times of eruption of the permanent teeth.

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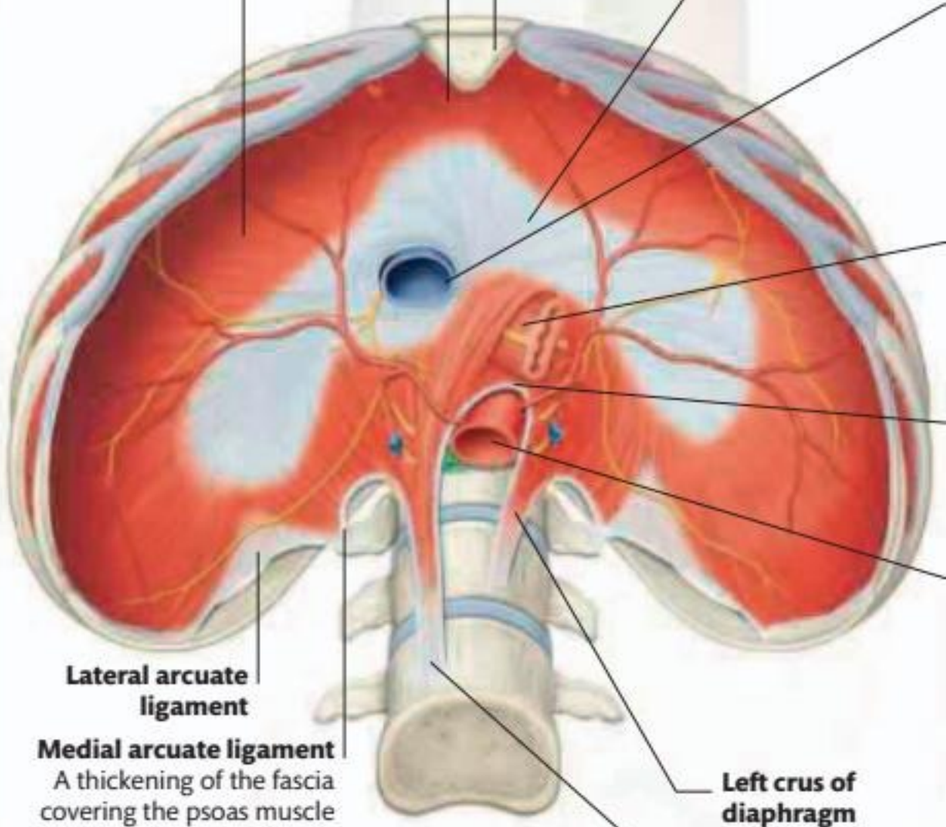
Esophagus
In the neck, the esophagus lies behind the trachea

Thoracic part of the esophagus
The esophagus is slightly constricted here by the left main bronchus, which crosses in front of it

Liver
Lies under the right dome of the diaphragm, and largely under cover of the ribs



DIAPHRAGM FROM BELOW

Inferior vena cava
Passes through the diaphragm level with the tenth thoracic vertebra

Esophagus
Passes through the diaphragm level with the tenth thoracic vertebra

Median arcuate ligament
Formed by fibers from both crura

Aorta
Passes behind the diaphragm, in front of the twelfth thoracic vertebra

ANTERIOR (FRONT)

Fundus of stomach
The upper part of the stomach lies below the left dome of the diaphragm, under the ribs

THORAX

There are several large tubes crammed into the space behind the heart. These include the descending aorta, the azygos vein, and the lymphatic duct, but also a part of the digestive tract—the esophagus. This tube of smooth muscle starts in the neck as a continuation of the pharynx. It runs down through the thorax, slightly to the left of center, and pierces through the diaphragm level with the tenth thoracic vertebra. A couple of centimeters below this, it empties into the stomach and ends. The esophagus, like much of the digestive tract, has an outer layer of longitudinal muscle and an inner layer of circular muscle within its wall. During swallowing, a wave of constriction passes downward to push food or fluid down into the stomach.

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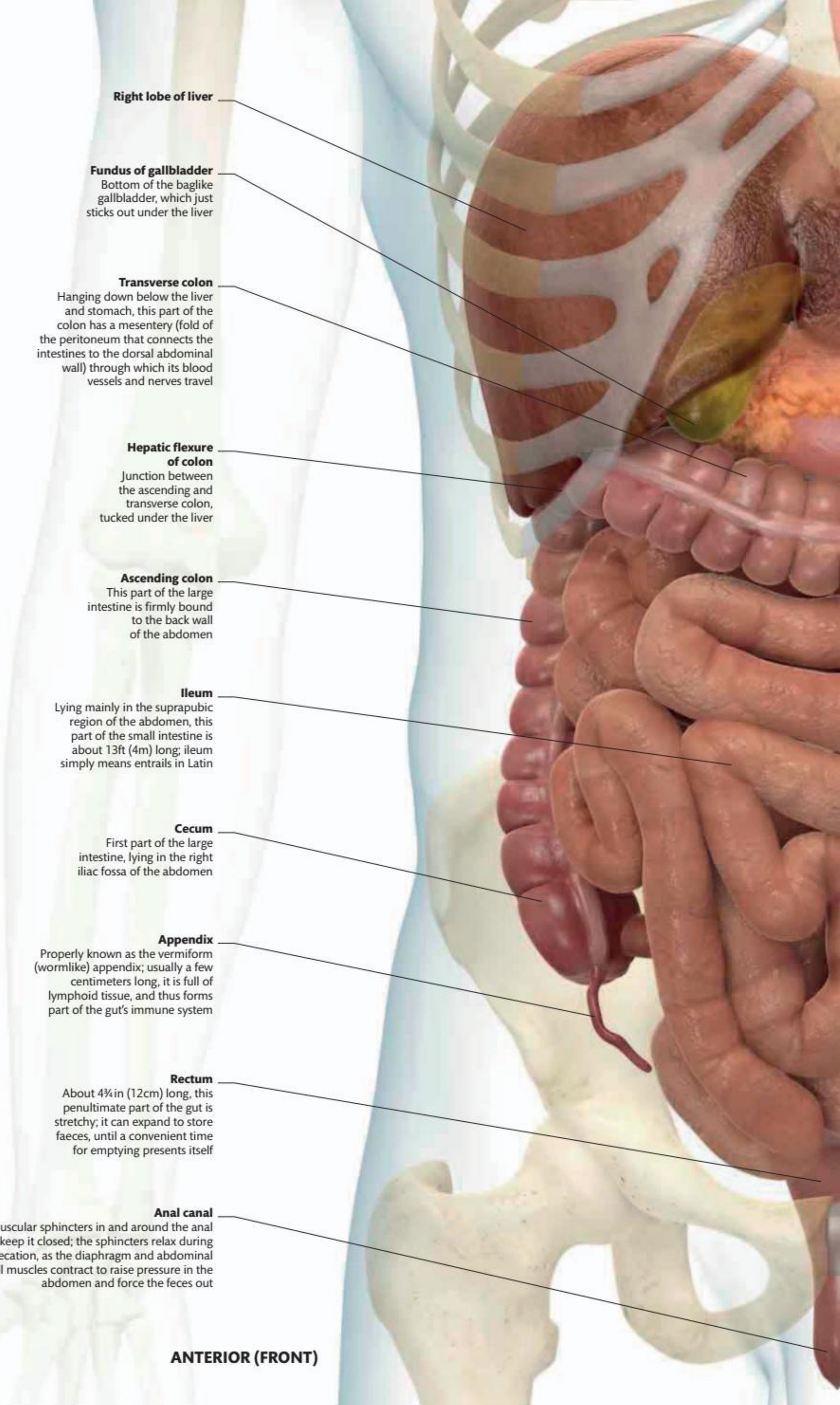


Right lobe of liver

Fundus of gallbladder
Bottom of the baglike gallbladder, which just sticks out under the liver

Transverse colon
Hanging down below the liver and stomach, this part of the colon has a mesentery (fold of the peritoneum that connects the intestines to the dorsal abdominal wall) through which its blood vessels and nerves travel

Hepatic flexure of colon
Junction between the ascending and transverse colon, tucked under the liver

Ascending colon
This part of the large intestine is firmly bound to the back wall of the abdomen

Ileum
Lying mainly in the suprapubic region of the abdomen, this part of the small intestine is about 13ft (4m) long; ileum simply means entrails in Latin

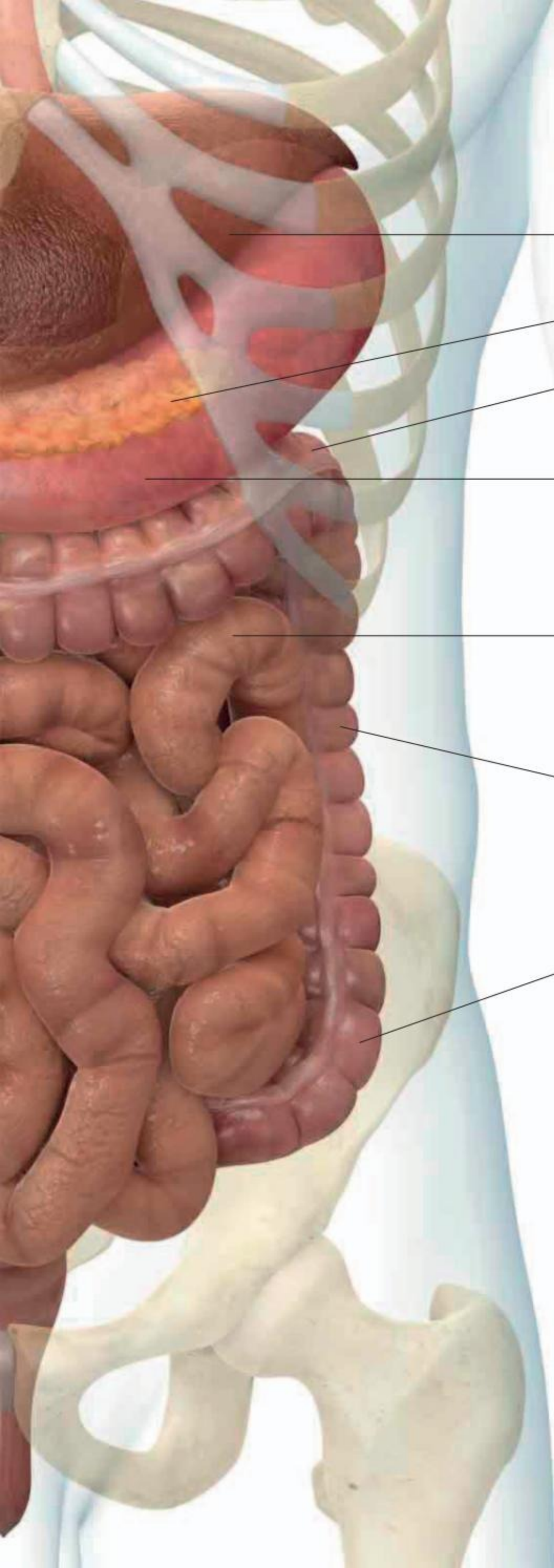
Cecum
First part of the large intestine, lying in the right iliac fossa of the abdomen

Appendix
Properly known as the vermiform (wormlike) appendix; usually a few centimeters long, it is full of lymphoid tissue, and thus forms part of the gut's immune system

Rectum
About 4¾in (12cm) long, this penultimate part of the gut is stretchy; it can expand to store faeces, until a convenient time for emptying presents itself

Anal canal
Muscular sphincters in and around the anal canal keep it closed; the sphincters relax during defecation, as the diaphragm and abdominal wall muscles contract to raise pressure in the abdomen and force the feces out

ANTERIOR (FRONT)



Left lobe of liver

Pancreas

Splenic flexure of colon
Junction between the transverse and descending colon, close to the spleen (spleen not shown here)

Stomach
The name comes originally from the Greek for gullet, but has come to mean this baglike part of the digestive system, just below the diaphragm

Jejunum
About 6½ft (2m) long, this part of the small intestine is more vascular (so slightly redder) than the ileum, and lies mainly in the umbilical region of the abdomen; its name comes from the Latin for empty—perhaps because food passes through here quickly

Descending colon
Like the ascending colon, this part of the large intestine has no mesentery, and is firmly bound to the back wall of the abdomen

Sigmoid colon
This S-shaped part of colon has a mesentery

ABDOMEN AND PELVIS

With the organs in situ, it is clear how much the abdominal cavity extends up under the ribs. The upper abdominal organs—the liver, stomach, and spleen—are largely under cover of the ribcage. This gives them some protection, but it also means that they are vulnerable to injury if a lower rib is fractured. The large intestine forms an M shape in the abdomen, starting with the cecum low down on the right, and the ascending colon running up the right flank and tucking under the liver. The transverse colon hangs down below the liver and stomach, and the descending colon runs down the left side of the abdomen. This becomes the S-shaped sigmoid colon, which runs down into the pelvis to become the rectum. The coils of the small intestine occupy the middle of the abdomen.

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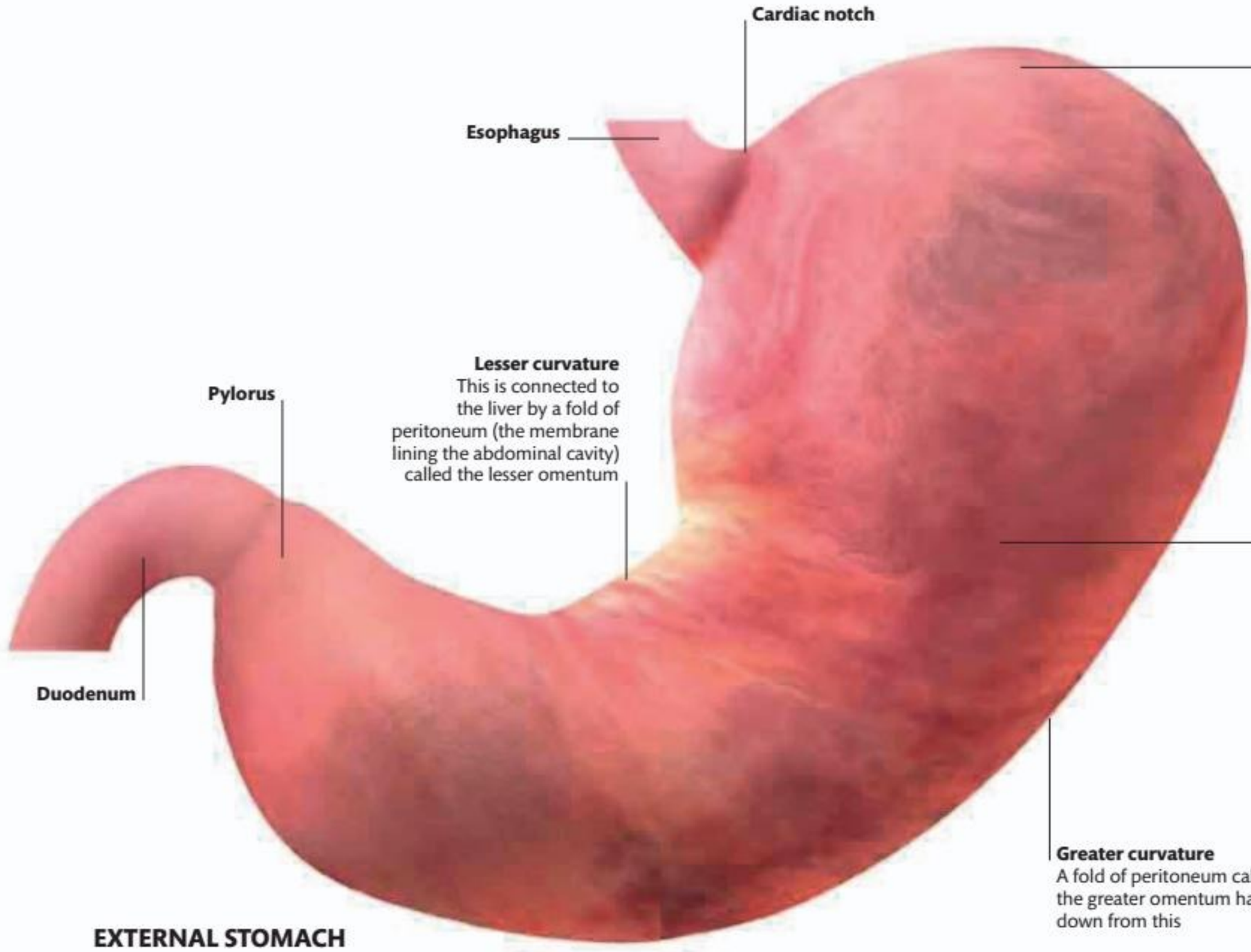
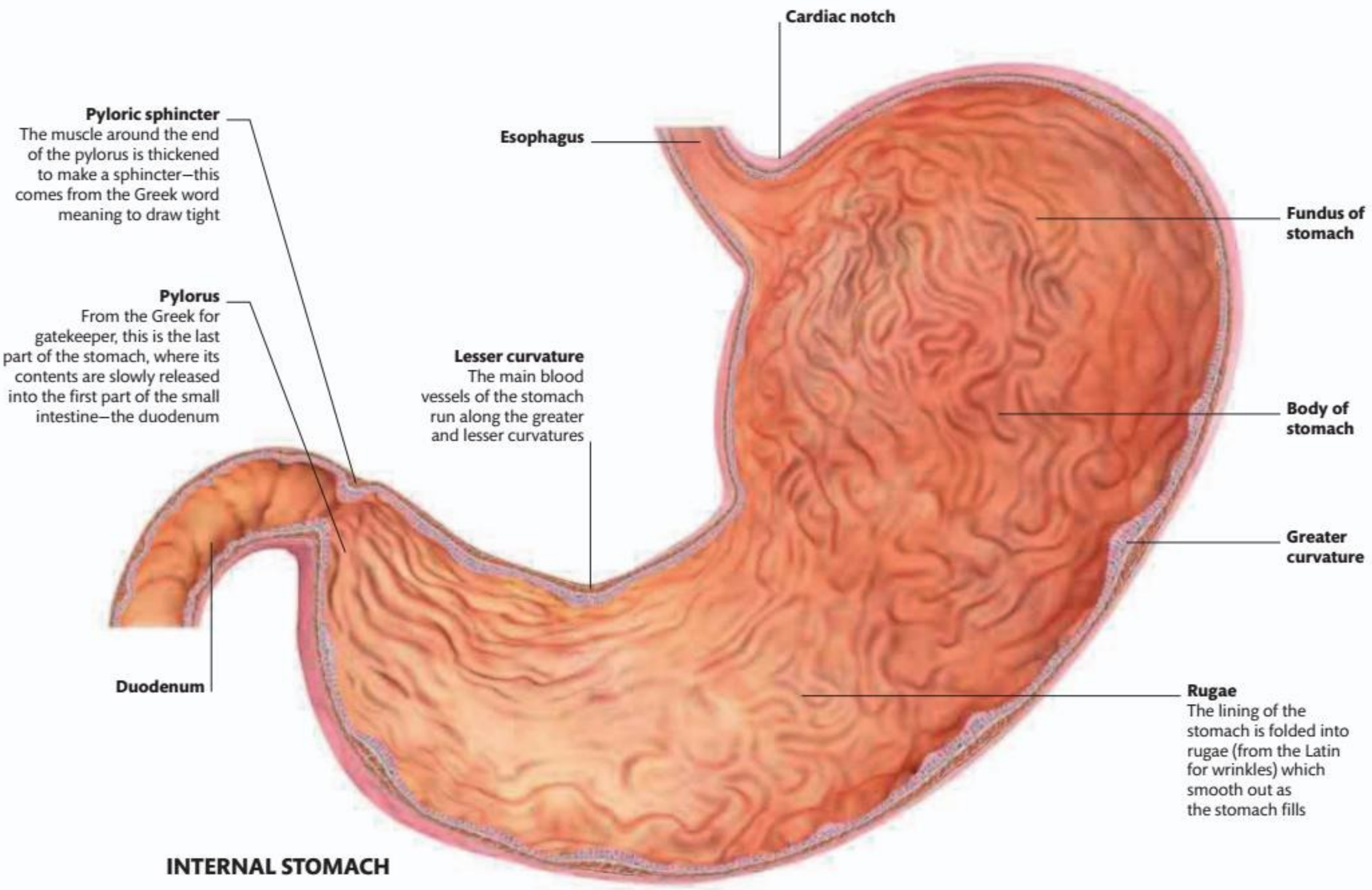


EXTERNAL STOMACH



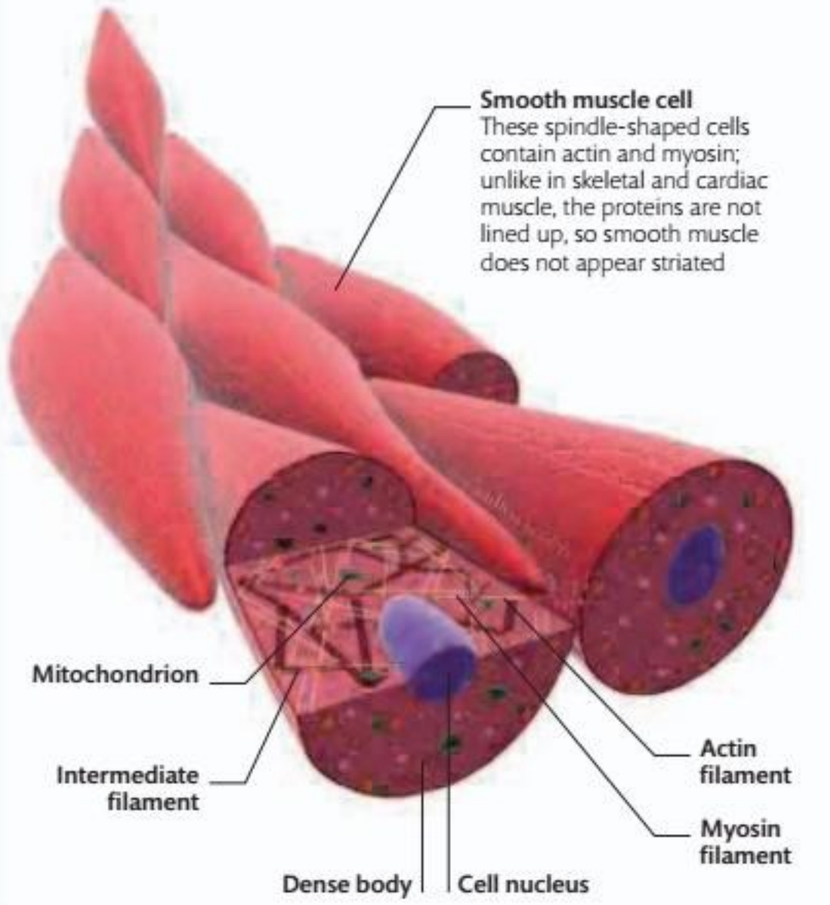
INTERNAL STOMACH

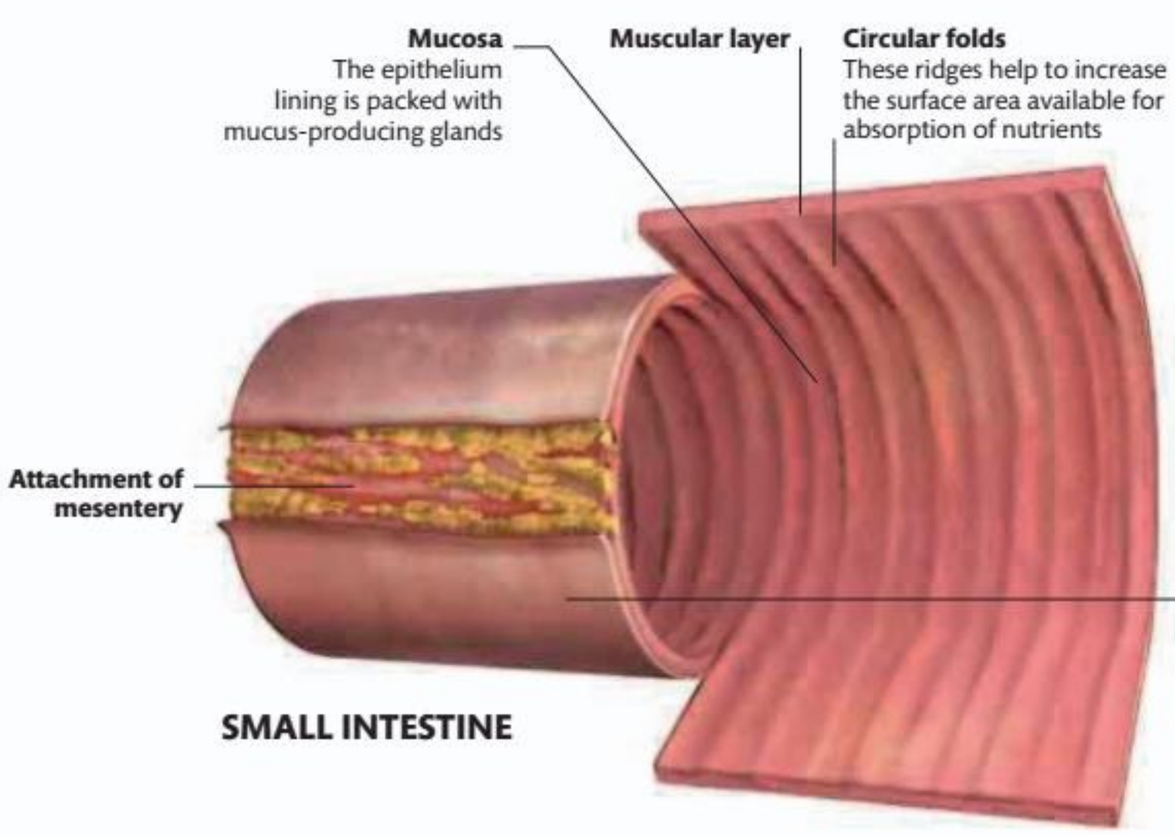
STOMACH AND INTESTINES

The stomach is a muscular bag, where food is held before moving on to the intestines. Inside the stomach, food is exposed to a cocktail of hydrochloric acid, which kills off bacteria, and protein-digesting enzymes. The layered muscle of the stomach wall contracts to churn up its contents. Semidigested food is released from the stomach into the first part of the small intestine, the duodenum, where bile and pancreatic juices are added. Contractions in the intestine wall then push the liquid food into the jejunum and ileum, where digestion continues. What is left passes into the cecum, the beginning of the large intestine. In the colon, the next part of the large intestine, water is absorbed so that the gut contents become more solid. The resulting feces pass into the rectum, where they are stored until excretion.

SMOOTH MUSCLE STRUCTURE

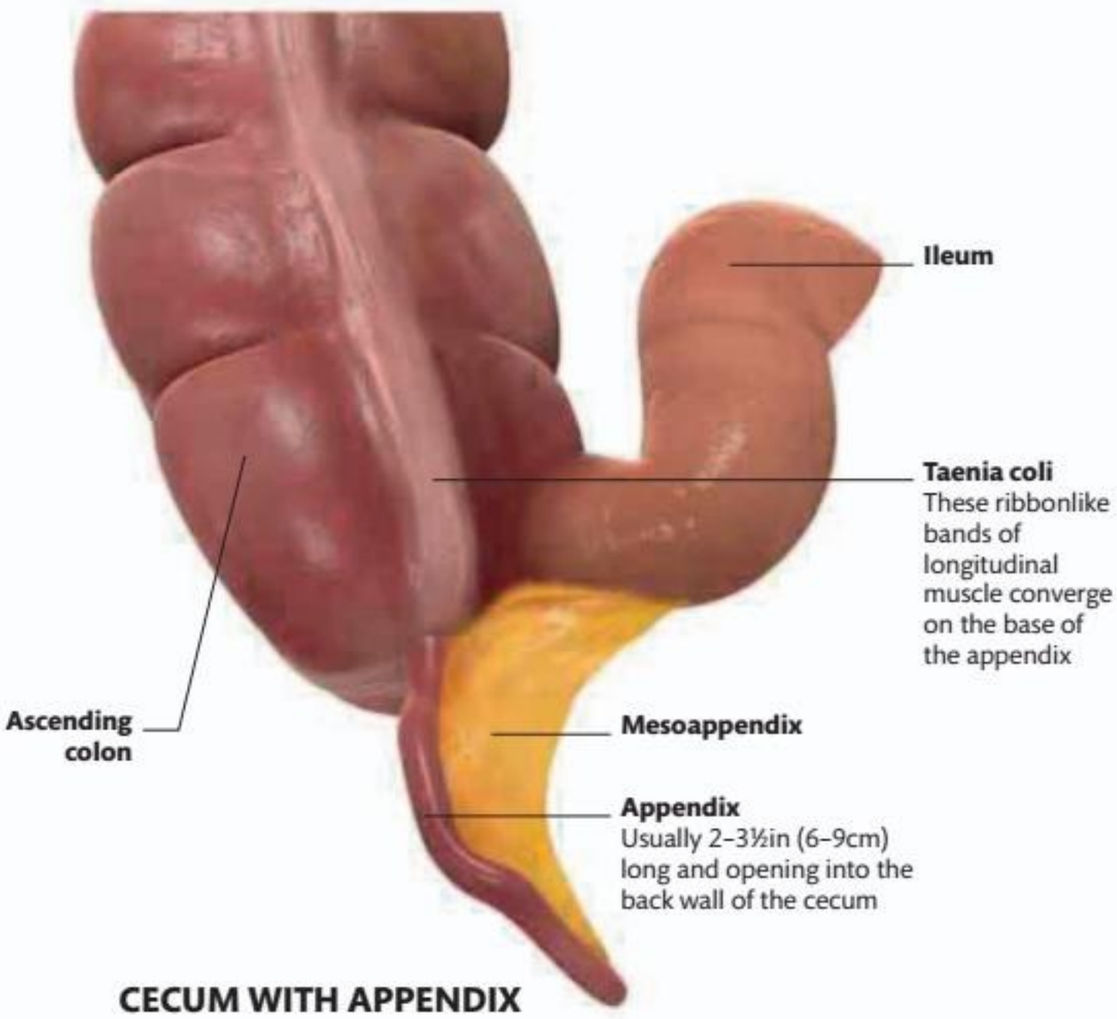
Functions of the gut, blood vessels, and respiratory tract are carried out involuntarily, at a subconscious level, with the help of a special type of muscle called smooth muscle. This is supplied by autonomic motor nerves.





SMALL INTESTINE

LARGE INTESTINE



CECUM WITH APPENDIX

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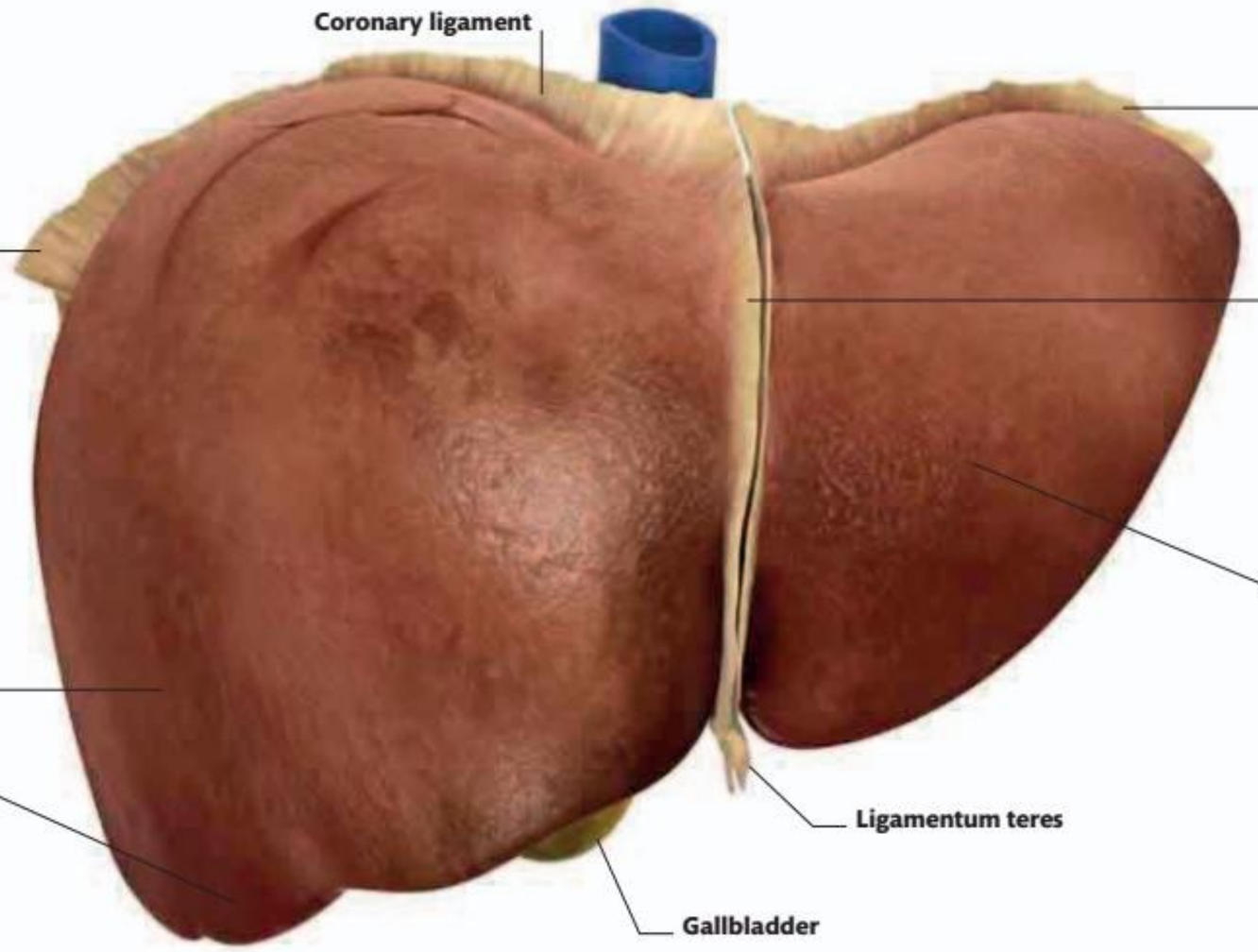
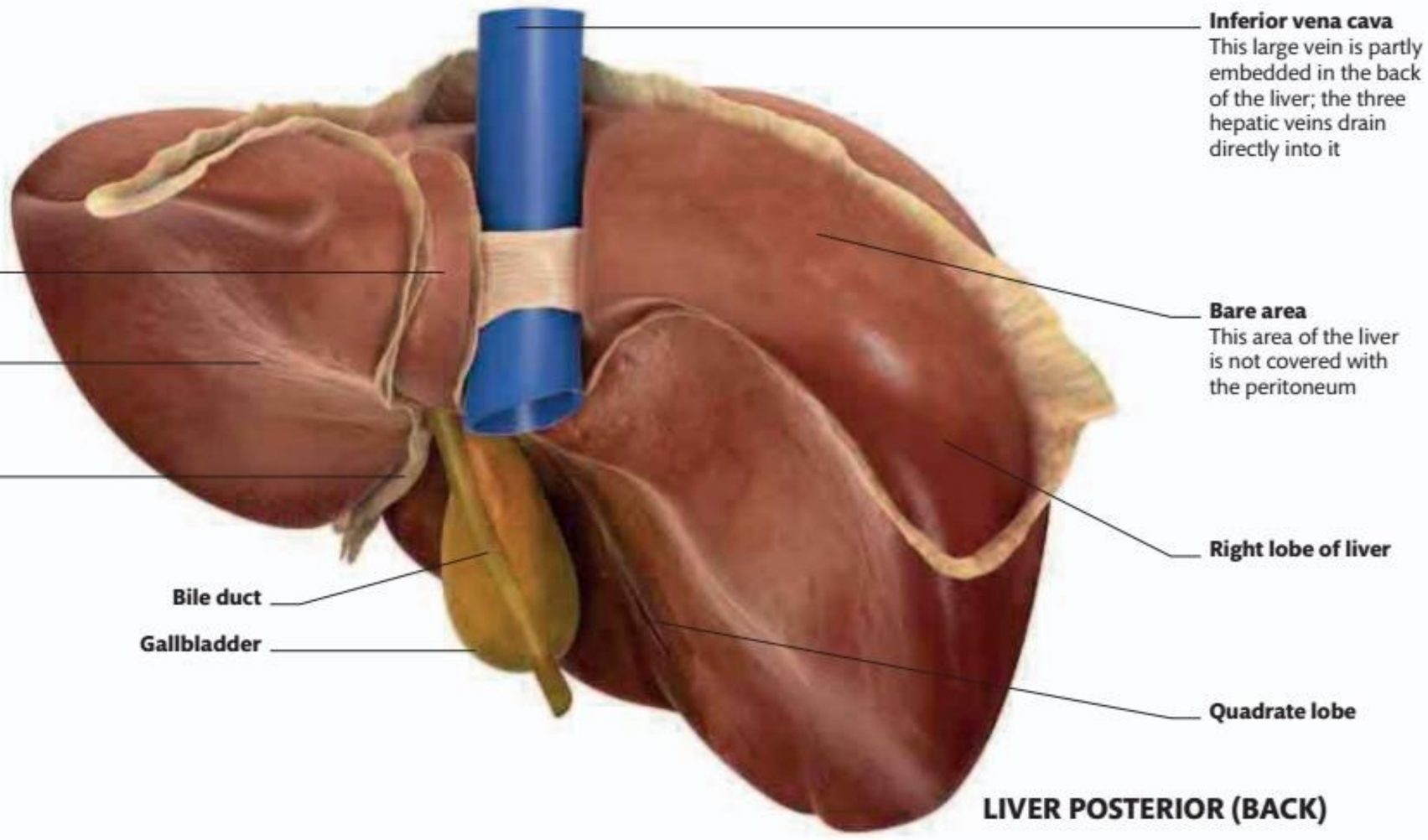
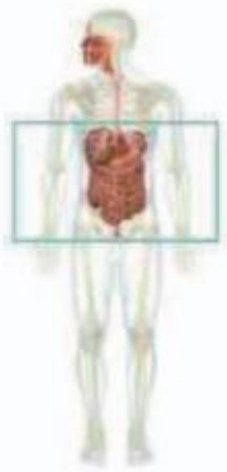


LIVER ANTERIOR (FRONT)

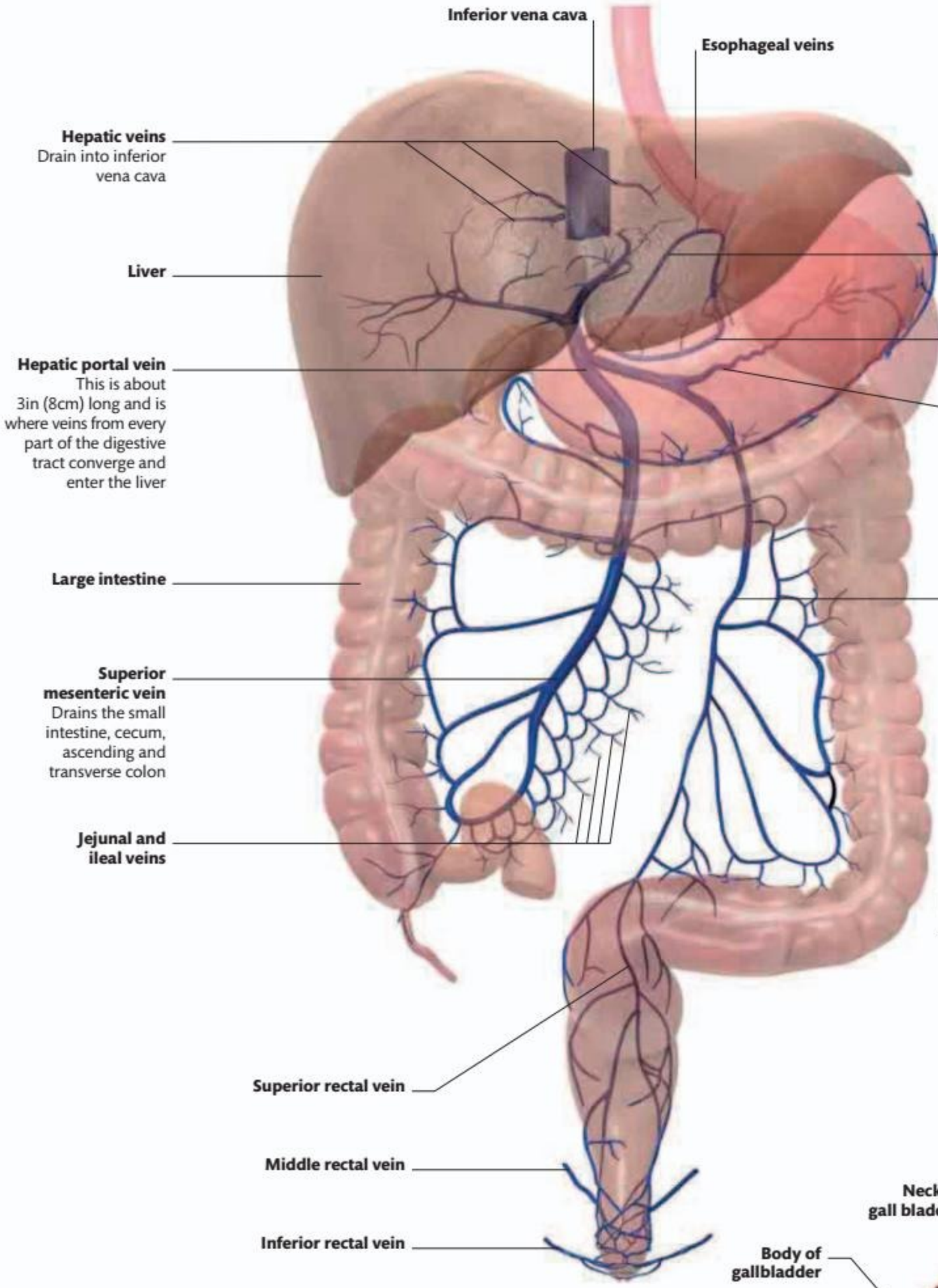


LIVER POSTERIOR (BACK)

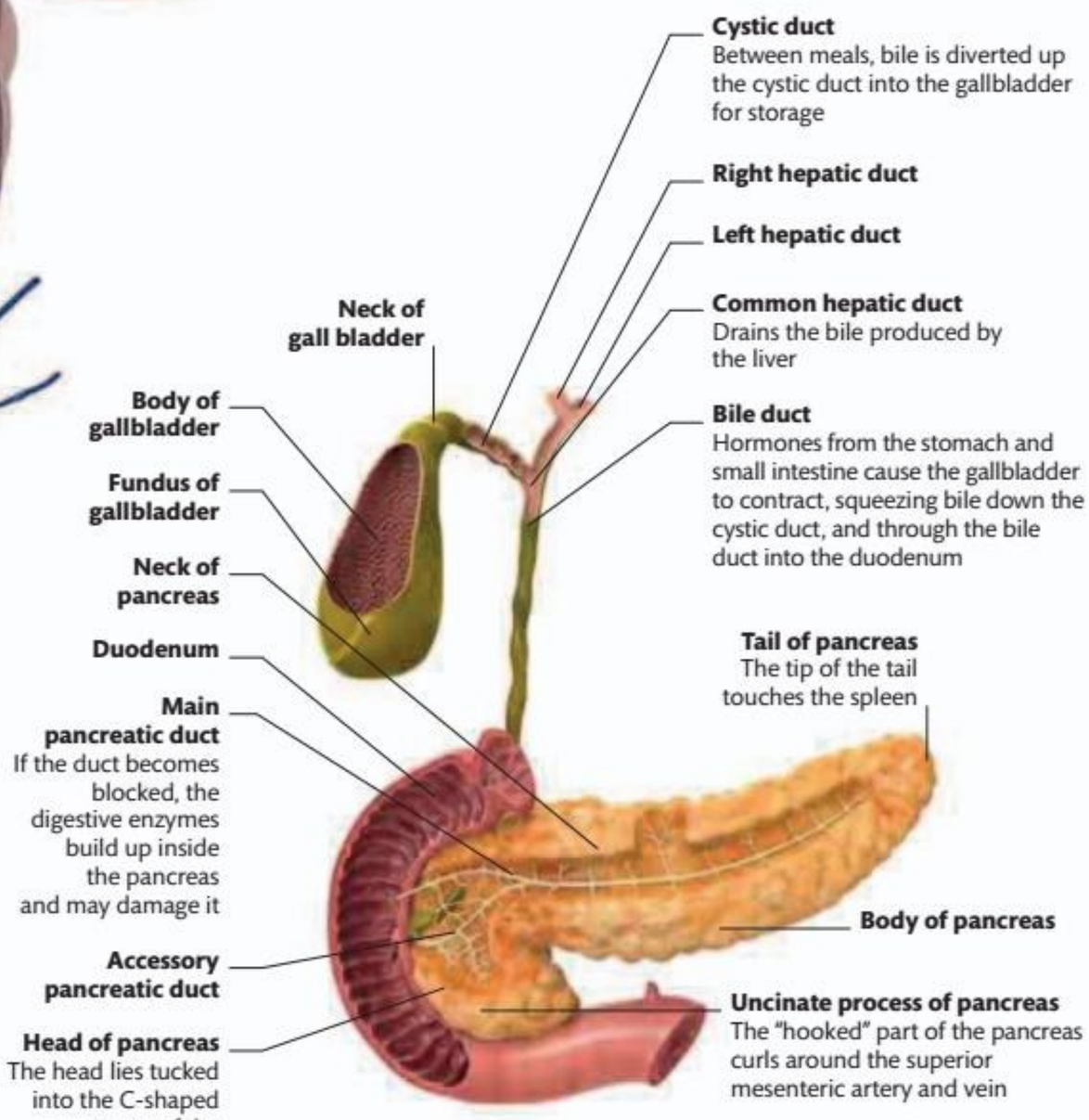


LIVER, PANCREAS, AND GALLBLADDER

The liver, the largest internal organ, can weigh up to 6lb (3kg). It does hundreds of jobs simultaneously, many of them related to digestion. It produces bile, which is stored in the gallbladder and helps to digest fats. It also receives nutrients from the gut via the portal vein and processes them. It breaks down or builds up proteins, carbohydrates, and fats according to need; detoxifies or deactivates substances such as alcohol and drugs; and plays a role in the immune system. The pancreas, a long, thin, leaf-shaped gland lying under the liver and behind the stomach, produces hormones that are secreted into the blood, and makes pancreatic juice, full of digestive enzymes, which it empties into the duodenum.



PORTAL VEINS AND TRIBUTARIES



GALLBLADDER AND PANCREAS

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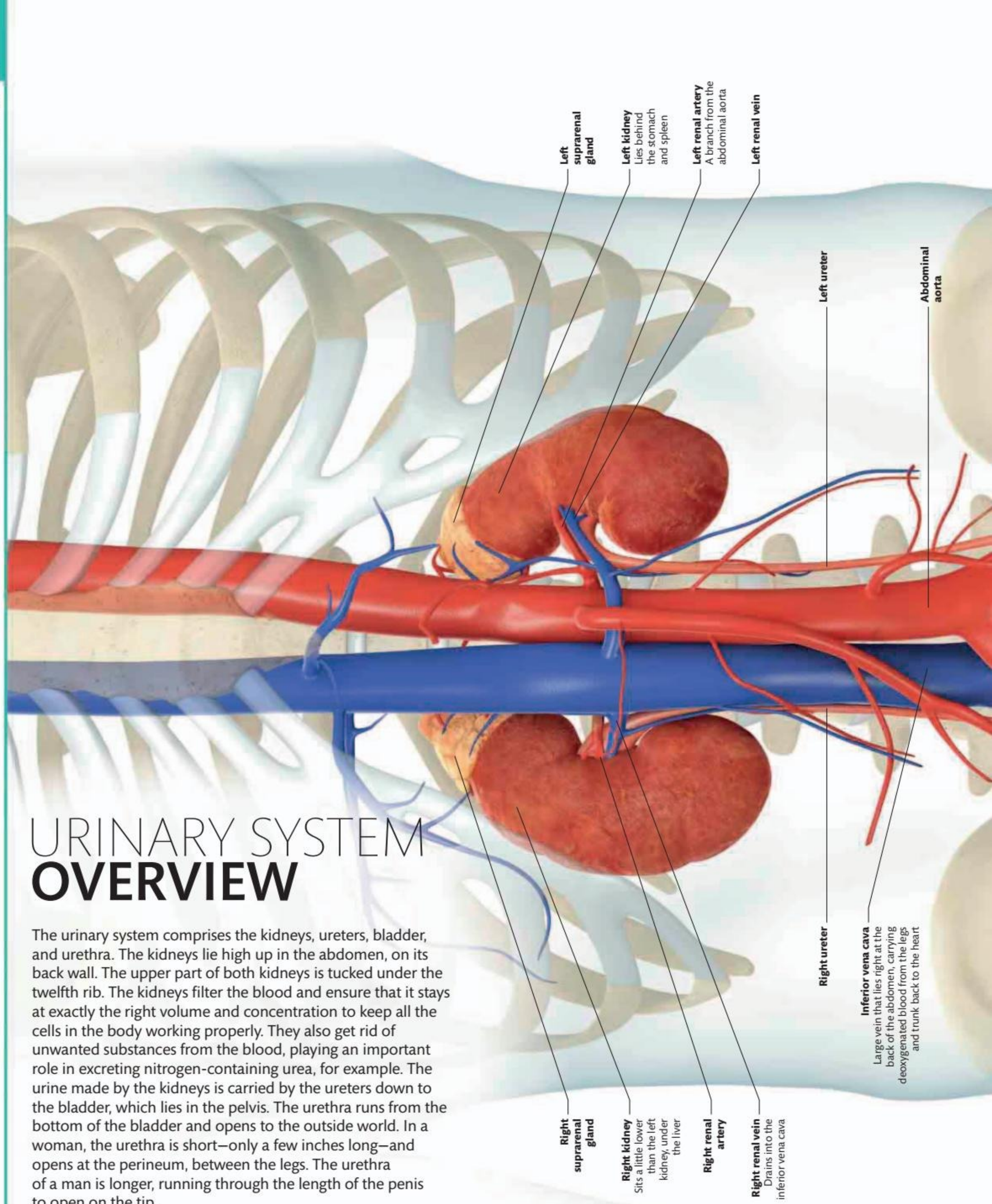
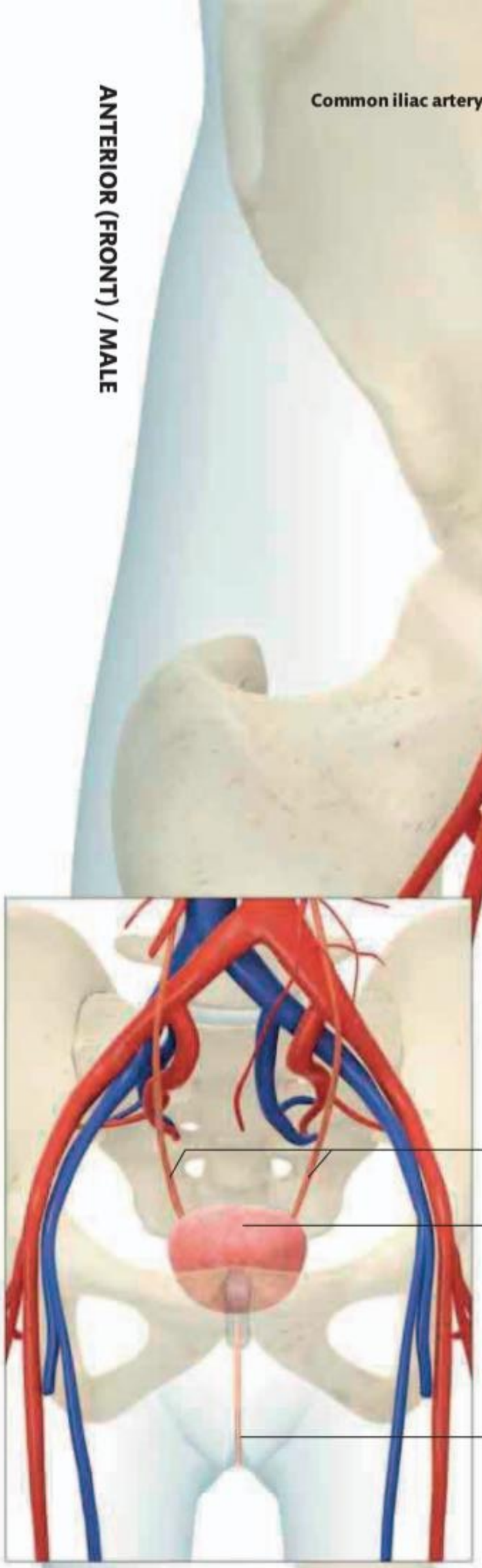
URINARY SYSTEM
OVERVIEW

The urinary system comprises the kidneys, ureters, bladder, and urethra. The kidneys lie high up in the abdomen, on its back wall. The upper part of both kidneys is tucked under the twelfth rib. The kidneys filter the blood and ensure that it stays at exactly the right volume and concentration to keep all the cells in the body working properly. They also get rid of unwanted substances from the blood, playing an important role in excreting nitrogen-containing urea, for example. The urine made by the kidneys is carried by the ureters down to the bladder, which lies in the pelvis. The urethra runs from the bottom of the bladder and opens to the outside world. In a woman, the urethra is short—only a few inches long—and opens at the perineum, between the legs. The urethra of a man is longer, running through the length of the penis to open on the tip.





ANTERIOR (FRONT) / FEMALE

Ureters

Bladder

Urethra
The female urethra is around 1½in (4cm) long. It passes through the muscle of the pelvic floor and a muscular sphincter, before opening between the clitoris and vagina

ANTERIOR (FRONT) / MALE

Common iliac artery

Common iliac vein

Bladder
A muscular bag that can hold up to 1 pint (0.5 litres) of urine

Prostate gland
Surrounds the commencement of the male urethra

Urethra
The male urethra is about 8in (20cm) long

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Suprarenal gland

Upper pole

Right kidney

Right renal artery
Renal comes from the Latin for kidney

Hilum
Where the artery enters and the vein and ureter exit the kidney; the word just means small thing in Latin, but is used in botany to describe the area on a seed where the seed vessel attaches, such as the eye of a bean

Right renal vein

Lower pole

Inferior vena cava

Right common iliac vein

Right internal iliac vein
Veins from the bladder eventually drain into the internal iliac veins

Right internal iliac artery
Vesical branches of the internal iliac artery supply the bladder

Right external iliac vein

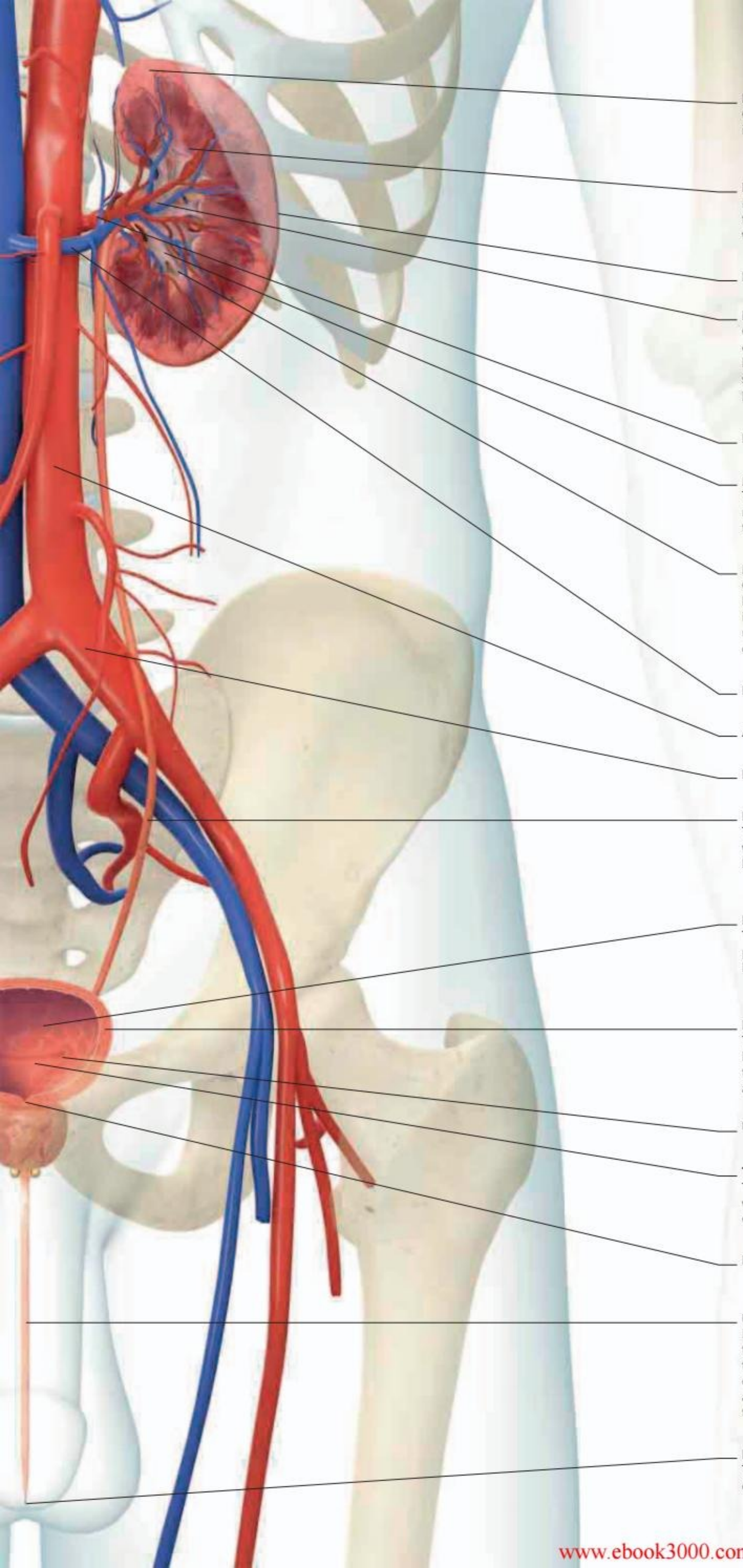
Right external iliac artery

Right ureter
The two ureters are muscular tubes: peristaltic (wavelike) contractions pump urine down into the bladder, even if you stand on your head; each ureter is about 10in (25cm) long

ANTERIOR (FRONT)

ABDOMEN AND PELVIS

The kidneys lie high up on the back wall of the abdomen, tucked up under the twelfth ribs. A thick layer of perinephric fat surrounds and protects each kidney. The kidneys filter the blood, which is carried to them via the renal arteries. They remove waste from the blood, and keep a tight check on blood volume and concentration. The urine they produce collects first in cup-shaped calyces, which join to form the renal pelvis. The urine then flows out of the kidneys and down narrow, muscular tubes called ureters to the bladder in the pelvis. The bladder is a muscular bag that can expand to hold up to about 1 pint (0.5 litres) of urine, and empties itself when the individual decides it is convenient. Urine travels through the urethra before leaving the body.



Renal cortex
Cortex means rind or bark; this is the outer tissue of the kidney

Renal medullary pyramid
Medulla means marrow or pith; this core tissue of the kidney is arranged as pyramids, which look triangular in cross section

Left kidney

Renal pelvis
Collects all urine from the kidney, and empties into the ureter; pelvis means basin in Latin, and the renal pelvis should not be confused with the bony pelvis—also shaped like a large basin

Left renal artery

Major calyx
The major calyces collect urine from the minor calyces, then themselves join together to form the renal pelvis

Minor calyx
Calyx originally meant flower covering in Greek, but because it is similar to the Latin word for cup it is used to describe cup-shaped structures in biology; urine from the microscopic collecting tubules of the kidney flows out into the minor calyces

Left renal vein

Abdominal aorta

Left common iliac artery

Left ureter
This name comes from the Greek for to make water; the two ureters carry urine from the kidneys to the bladder

Bladder
The empty bladder lies low down, in the true pelvis, behind the pubic symphysis; as the bladder fills, it expands up into the abdomen

Detrusor muscle
The crisscrossing smooth muscle bundles of the bladder wall give the inner surface of the bladder a netlike appearance

Ureteric orifice

Trigone
The three-cornered region of the back wall of the bladder, between the ureteric orifices and the internal urethral orifice

Internal urethral orifice

Urethra
From the Greek for urinate; this tube carries urine from the bladder to the outside world, a distance of around 1½in (4cm) in women, and about 8in (20cm) in men (as it travels the length of the penis)

External urethral orifice
The male urethra opens at the tip of the glans penis

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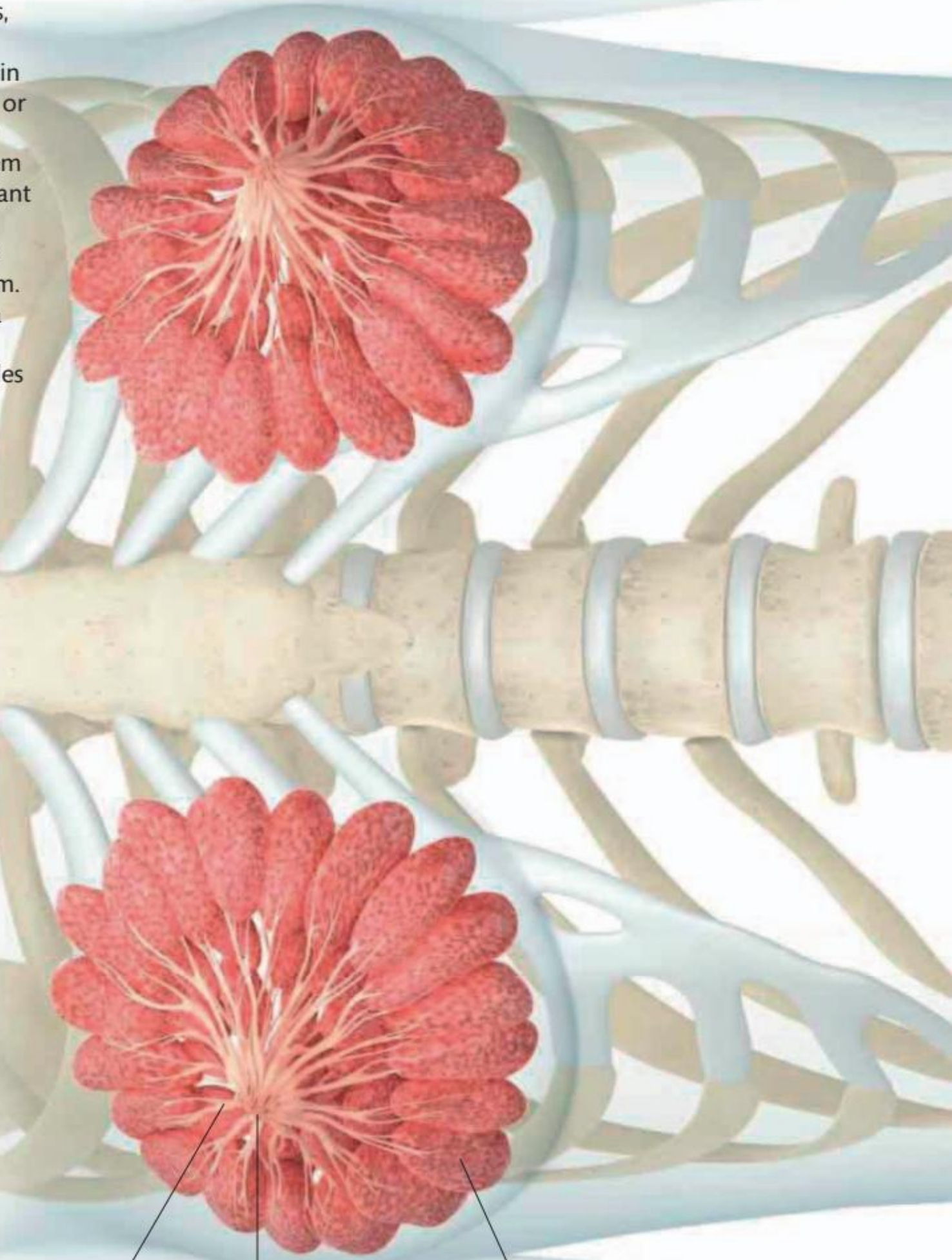
REPRODUCTIVE SYSTEM **OVERVIEW**

Most organs in the body are similar in men and women. However, when it comes to the reproductive organs, there is a world of difference. In a woman, the ovaries, which produce eggs and female sex hormones, are tucked away, deep inside the pelvis. Also located within the pelvis are the vagina, uterus, and paired oviducts, or fallopian tubes, in which eggs are conveyed from the ovaries to the uterus. The woman's reproductive system also includes the mammary glands, which are important in providing milk for the newborn.

In a man, the testes, which produce sperm and sex hormones, hang well outside the pelvis, in the scrotum. The rest of the male reproductive system consists of a pair of tubes called the vasa deferentia (singular, vas deferens), the accessory sex glands (the seminal vesicles and the prostate), and the urethra.



ANTERIOR (FRONT) / FEMALE

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Oviduct
Also known as fallopian tubes, oviducts collect eggs produced at ovulation and transport them to the uterus; oviducts are also the place where fertilization normally occurs

Fimbriae
Fingerlike projections that form a feathery end to each oviduct

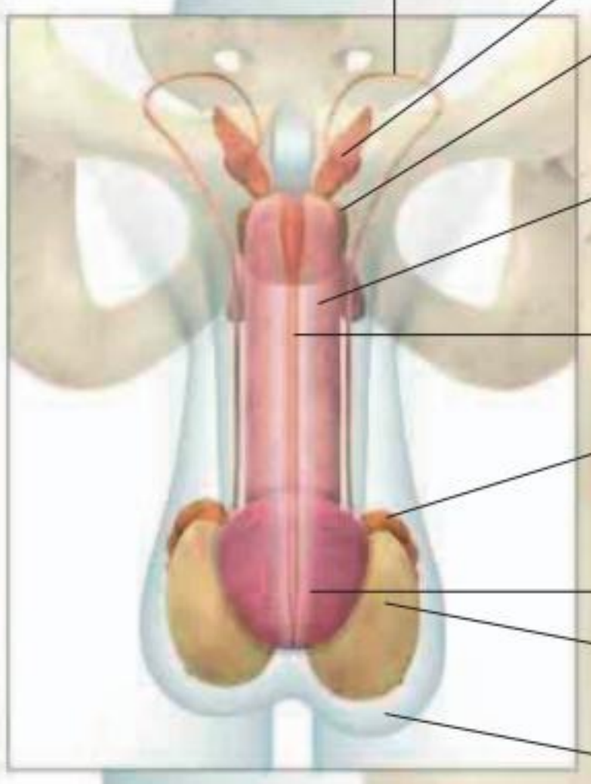
Ovary
Female gonad; is hidden away, deep within the pelvis

Fundus of uterus
The uterus is angled forward, so the fundus—the farthest point from the opening—lies toward the front

Body of uterus

Cervix of uterus
The cervix, or neck of the uterus, projects down into the vagina

Vagina
Flexible muscular tube that accommodates the male penis during coitus; during childbirth, it expands to allow the fetus to pass through



Seminal vesicle
Contributes fluid to semen

Prostate gland
Accessory gland located at the base of the bladder; contributes some fluid to semen

Shaft of penis
Formed by masses of erectile tissue, which become engorged with blood during erection

Urethra
Conveys sperm and urine through penis

Epididymis
A tightly-coiled tube on the back of the testis; sperm are stored and mature here

Glans penis

Testis
Male gonad; hangs outside body cavity, in the scrotum

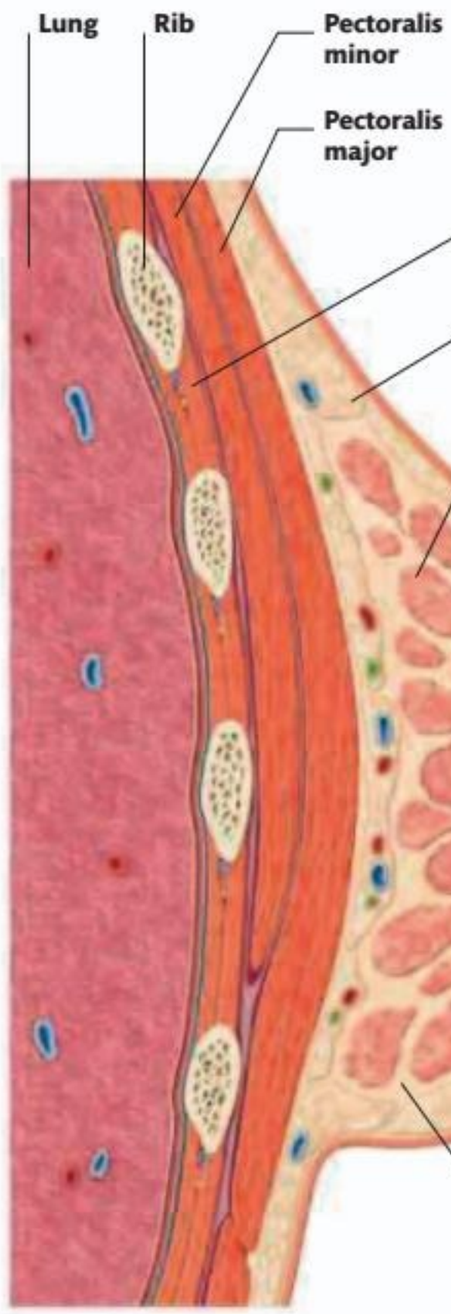
Scrotum
Pouch of skin and muscle that encases testis

ANTERIOR (FRONT) / MALE

Axillary tail
This part of the illustration shows the extent of the breast; breast tissue continues upward and outward on the chest wall—right up into the axilla (armpit)

Nipple

Areola
Means small area in Latin



CROSS SECTION OF BREAST

ANTERIOR (FRONT) / FEMALE

Lactiferous duct
From the Latin for milk-carrying duct

Secretory lobule
Lactiferous ducts branch during puberty to form lobules, where milk is produced and secreted

THORAX

The breasts, or mammary glands, are an important part of the reproductive system in women. Like all other mammals, human females have mammary glands to provide the newborn with milk. But while many mammals have multiple mammary glands, humans (and other apes) have just two, on the front of the chest. The breasts develop at puberty, when they grow due to the increased production of glandular tissue and fat. The breasts lie on the pectoralis major muscle on each side. Each breast contains 15 to 20 lobes, which are connected to the nipple by lactiferous ducts. There seems to be a basic plan in the developing embryo, so that male nipples appear, although the breast does not form.

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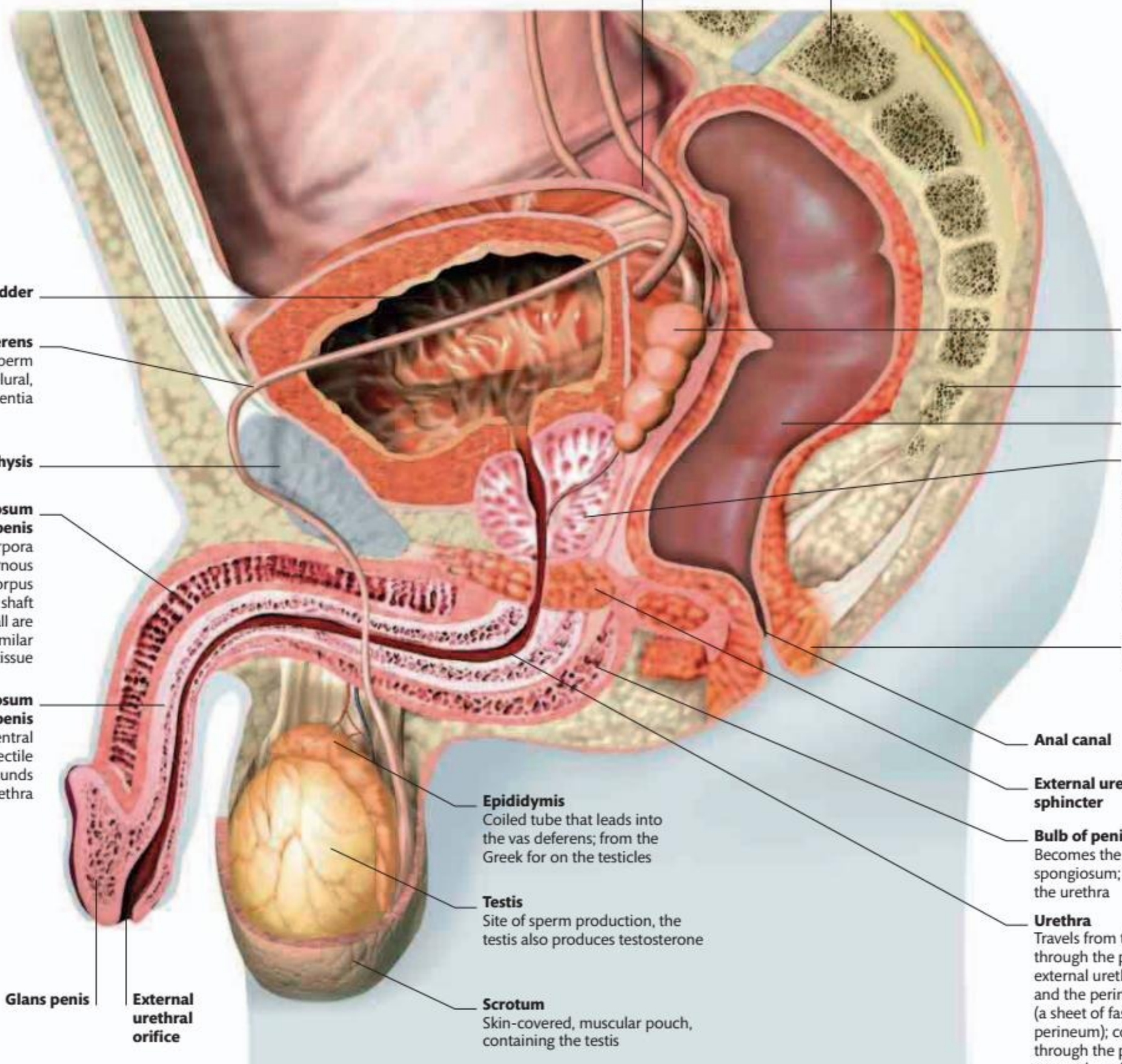
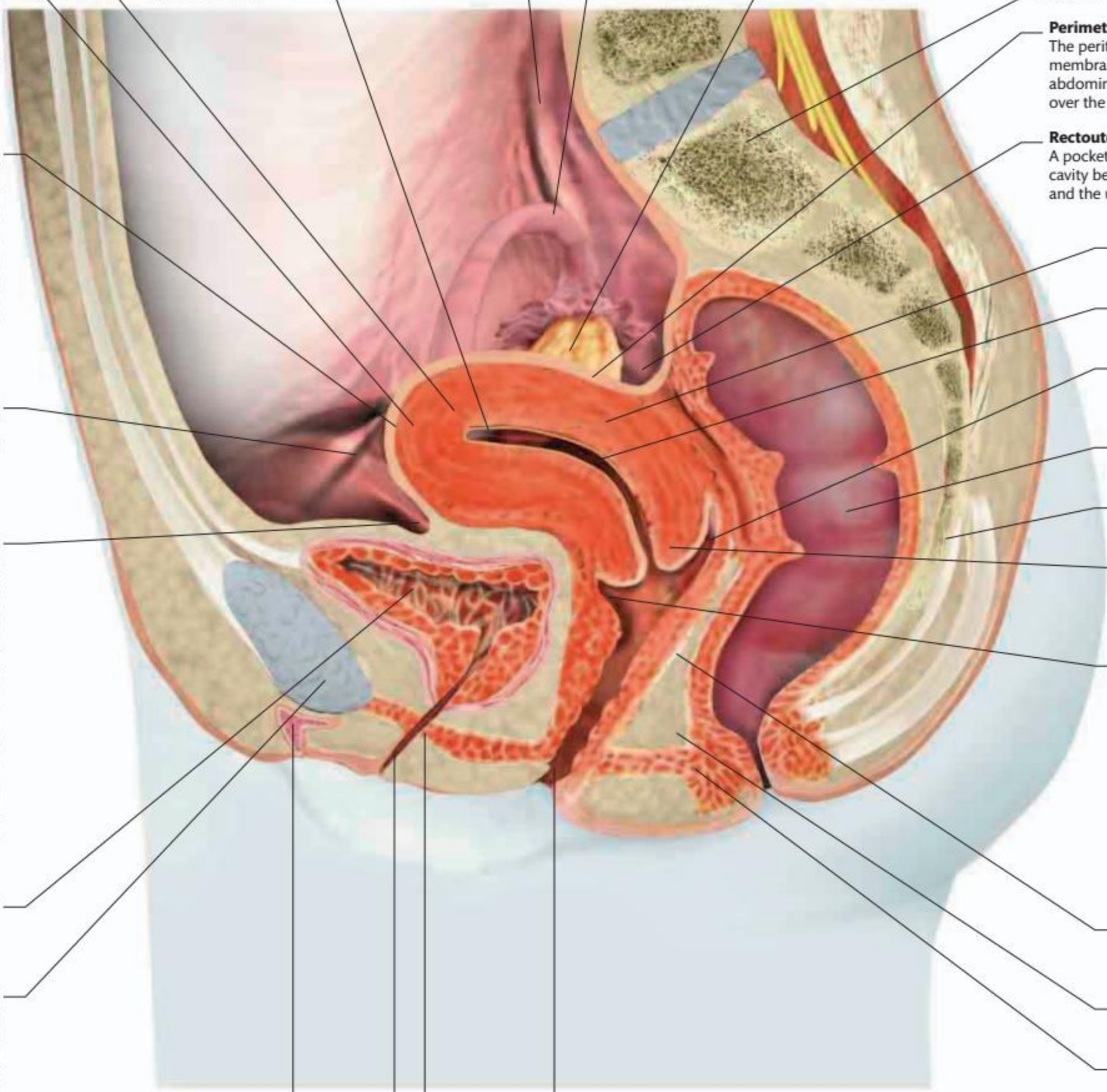


SAGITTAL SECTION / MALE

ABDOMEN AND PELVIS

The male and female reproductive systems are both comprised of a series of internal and external organs, although structurally these are very different. It is true that both sexes possess gonads (ovaries in women and testes in men) and a tract, or set of tubes, but the similarity ends there. When we look in detail at the anatomy of the pelvis in each sex, the differences are obvious. The pelvis of a man contains only part of the reproductive tract, as well as the lower parts of the digestive and urinary tracts, including the rectum and bladder. Beneath the bladder is the prostate gland; this is where the vasa deferentia, which bring sperm from the testis, empty into the urethra. A woman's pelvic cavity contains more of the reproductive tract than a man's. The vagina and uterus are situated between the bladder and rectum in the pelvis.



Myometrium
Thick, smooth muscle layer of uterus

Fundus of uterus
The top portion of the uterus, farthest from the cervix

Uterus
The uterus is shaped like a flattened pear, and normally lies in the position shown here—bent forward over an empty bladder

Round ligament of the uterus

Vesicouterine pouch
A pocket of peritoneal cavity between the bladder and the uterus. The peritoneal cavity is a potential space between the peritoneum lining the abdominal walls, and the abdominal and pelvic organs

Bladder

Pubic symphysis
Cartilage joint at front of pelvis; softens during pregnancy then widens slightly during childbirth

Endometrium
Lining of the uterus; innermost layer of endometrium is shed during menstruation. From the Greek for within the womb

Suspensory ligament of ovary
Carries ovarian arteries and veins to and from the ovary

Oviduct
Literally, egg-duct; each one is about 4in (10cm) long

Ovary
Means egg place in Latin; each of the two ovaries lies on the pelvic side wall, in the angle between the internal and external iliac arteries

Sacrum

Perimetrium
The peritoneum (serous membrane lining the abdominal cavity) lies over the uterus

Rectouterine pouch
A pocket of peritoneal cavity between the rectum and the uterus

Body of uterus

Cavity of uterus

Posterior fornix of vagina

Rectum

Coccyx

Cervix of uterus
Literally, the neck of the uterus

Anterior fornix of vagina
Fornices are gutter-like areas that form as the cervix projects down into the vagina, known as anterior, lateral, and posterior fornices; fornix means arch or vault in Latin

Rectovaginal septum

Anal canal

External anal sphincter

Clitoris
Contains spongy, erectile tissue similar to that in the penis

Urethra

External urethral sphincter

Vagina
Tube, around 3½in (9cm) long, with walls of fibrous and muscular tissue

SAGITTAL SECTION / FEMALE

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PENIS AND TESTES

Seminal vesicle
One of a pair of accessory reproductive glands; contributes to seminal fluid

Ureter

Bladder

Prostate gland
Accessory reproductive gland; contributes about a third of all seminal fluid

Cowper's gland
One of two pea-sized glands, also known as bulbourethral glands; secretes a tiny portion of seminal fluid

Bulb of penis
Part of the root of the penis; attaches to the perineal membrane, which stretches between the ischiopubic rami of the pelvis (see p.44)

Crus of penis
One of two crura that are attached to the ischiopubic rami and make up part of the root of the penis

Vas deferens
Muscular tube; carries sperm from the testis into the pelvis, via the abdominal cavity. It leads into the prostate and joins the duct of the seminal vesicle before entering the urethra

Epididymis
Can be felt through the scrotum as a long lump on the back of the testis

Efferent ductules
10–20 ductules carry seminal fluid from the testes to the epididymis

Rete testis
Literally meaning the network of testis; these interconnecting tubes link the seminiferous tubules with the efferent ductules

Lobule of testis
200–300 lobules lie in each testis; each contains 1–3 tightly-packed seminiferous tubules, in which sperm are made

Tunica albuginea
Literally meaning egg-white-like coat; the outer covering of the testis

Corporus cavernosa
One of two columns of tissue, formed where the crura join at the shaft of the penis; known together as corpora cavernosa

Corpus spongiosum
The bulb of the penis continues on to form spongy erectile tissue called the corpus spongiosum, or spongy body

Glans penis
Expanded part of the corpus spongiosum

CROSS SECTION OF PENIS

Dorsal artery
A branch of the internal pudendal artery, which is itself a branch of the internal iliac artery

Dorsal veins
These drain up to the venous plexus around the prostate and, ultimately, to the internal iliac veins

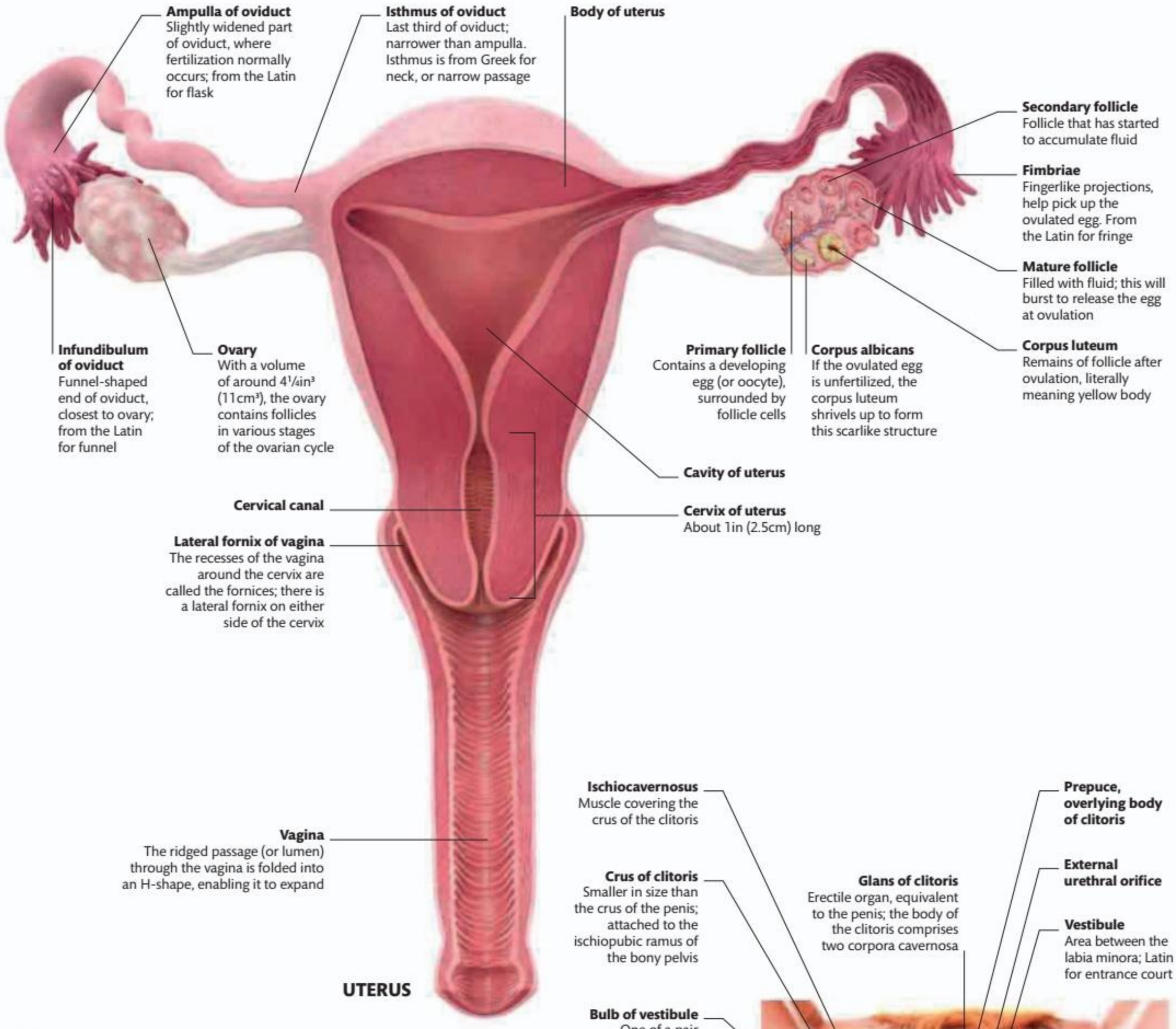
Septum
Fibrous division between the corpora cavernosa

Tunica albuginea
Fibrous envelope around the components of the penis

Corpora cavernosa

Urethra

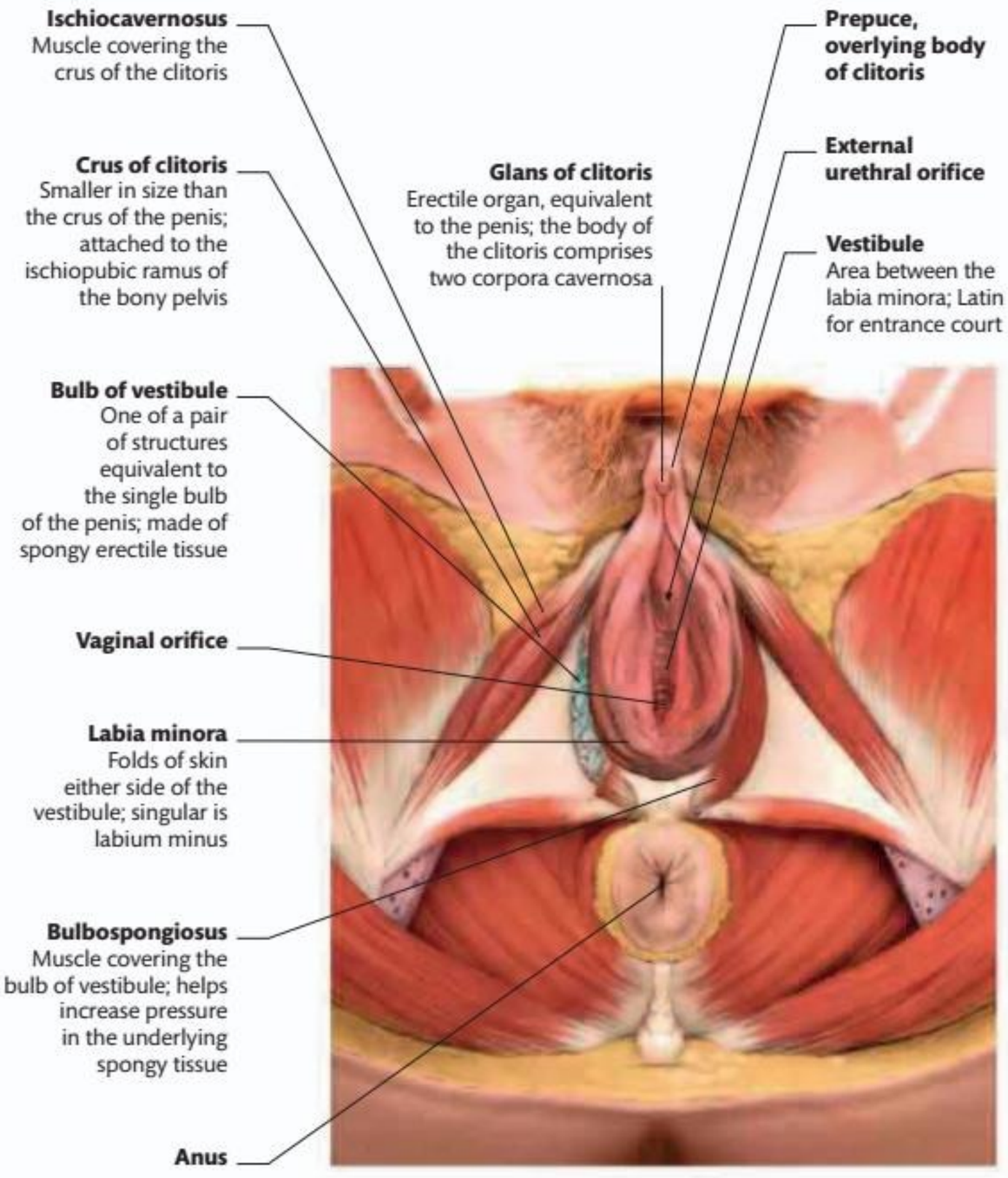
Corpus spongiosum



UTERUS

ABDOMEN AND PELVIS

At a very fundamental level, the reproductive systems of man and woman must work together to allow eggs and sperm to meet. These views of the isolated organs and reproductive tracts show clearly how the anatomy is arranged to achieve this. The ovaries, where eggs (or ova) are produced, are deep inside the female pelvis. The eggs are collected from the ovaries by a pair of tubes, the oviducts, and it is usually here that fertilization takes place. The fertilized egg then moves along the oviduct, dividing into a ball of cells. The embryo eventually reaches the uterus, which is designed to accommodate and support the growing fetus. The vagina provides both a way for sperm to get in, and the route for the baby to get out at birth.



EXTERNAL FEMALE GENITALIA

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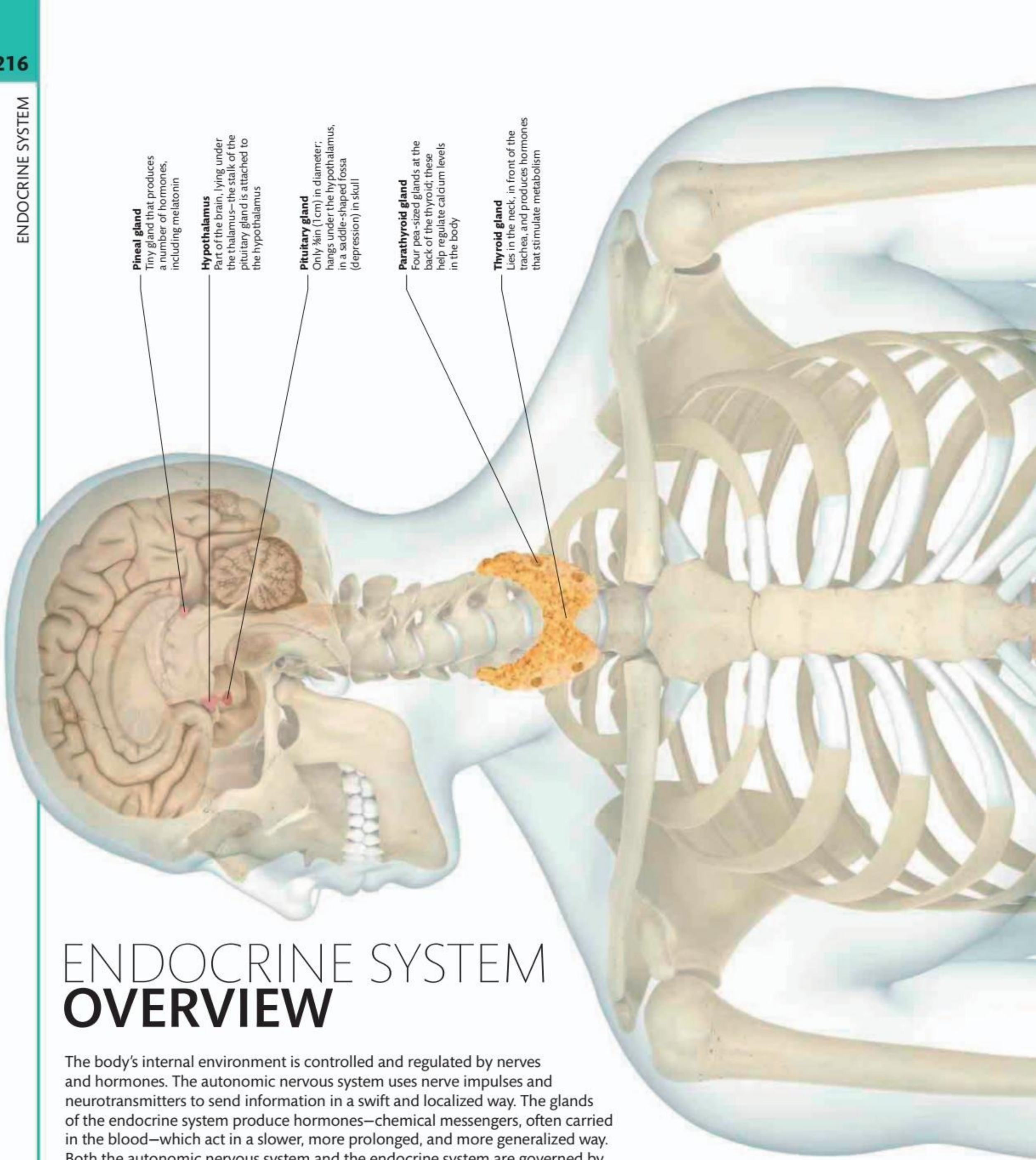

ENDOCRINE SYSTEM
OVERVIEW

The body's internal environment is controlled and regulated by nerves and hormones. The autonomic nervous system uses nerve impulses and neurotransmitters to send information in a swift and localized way. The glands of the endocrine system produce hormones—chemical messengers, often carried in the blood—which act in a slower, more prolonged, and more generalized way. Both the autonomic nervous system and the endocrine system are governed by the hypothalamus in the brain. The pituitary gland produces hormones that affect other endocrine glands, which sometimes form discrete organs. There are also hormone-producing cells in the tissues of many other organs.

ANTERIOR (FRONT)

Suprarenal gland
A pair of glands, also known as adrenal glands, that produce epinephrine, also called adrenaline

Pancreas
Has cells that produce hormones controlling glucose metabolism: insulin and glucagon; also produces digestive enzymes

Ovary
Ovaries produce sex hormones as well as gametes (reproductive cells) called ova

FEMALE

Testis
Testes produce sex hormones as well as gametes (reproductive cells) called sperm

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HEAD AND NECK

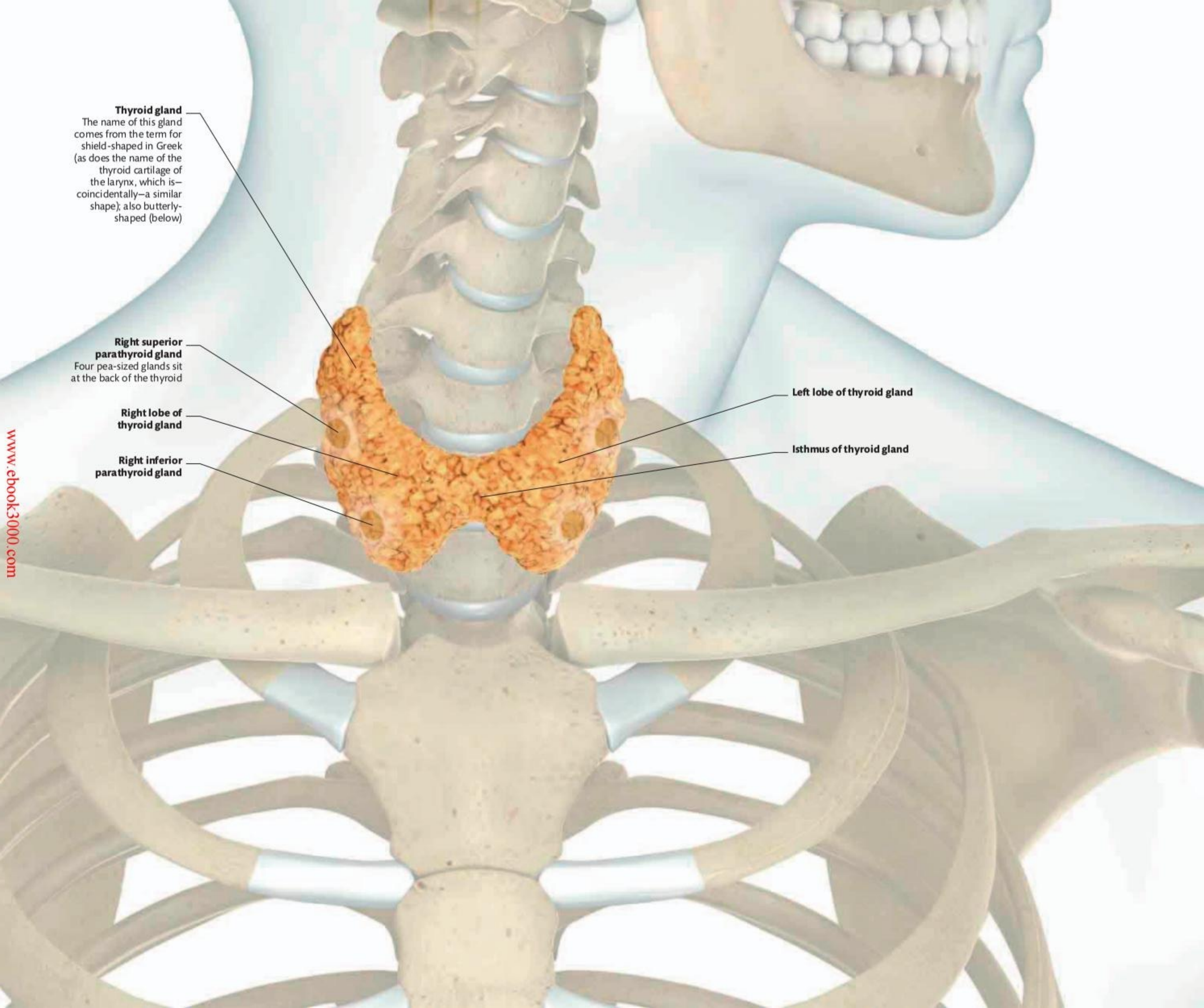
The insides of our bodies are regulated by the autonomic nervous and endocrine systems. There is overlap between these two systems, and their functions are integrated and controlled within the hypothalamus of the brain. The pituitary gland has two lobes; its posterior lobe develops as a direct extension of the hypothalamus. Both lobes of the pituitary gland secrete hormones into the bloodstream, in response to nerve signals or blood-borne releasing factors from the hypothalamus. Many of the pituitary hormones act on other endocrine glands, including the thyroid gland in the neck, the suprarenal glands on top of the kidneys, and the ovaries or testes.

Pituitary gland
The name of this gland commemorates a historical misapprehension: it comes from the Latin for mucus or phlegm, as it used to be thought—wrongly—that the pituitary gland secreted nasal mucus

Hypothalamus

Pineal gland
This tiny gland is about 5/16 in (8mm) long, and shaped a bit like a pine nut; it has links to the visual pathway, and is involved in regulating circadian rhythms—the daily sleep–wake cycle

SIDE



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03 Imaging the Body

The human body is a "living machine" with many complex working parts. To understand how the body functions, and to cure the various ailments that afflict it, it is crucial for medical professionals to examine it in detail. Advances in technology have made it possible to view human anatomy without dissecting the body. Techniques such as magnetic resonance imaging (MRI) reveal the inside of the body with great accuracy and allow us to build up a complete picture of our anatomy from every possible angle.

222 Imaging techniques
224 Head and neck
226 Thorax
228 Abdomen and pelvis
230 Lower arm and hand
232 Lower limb and foot

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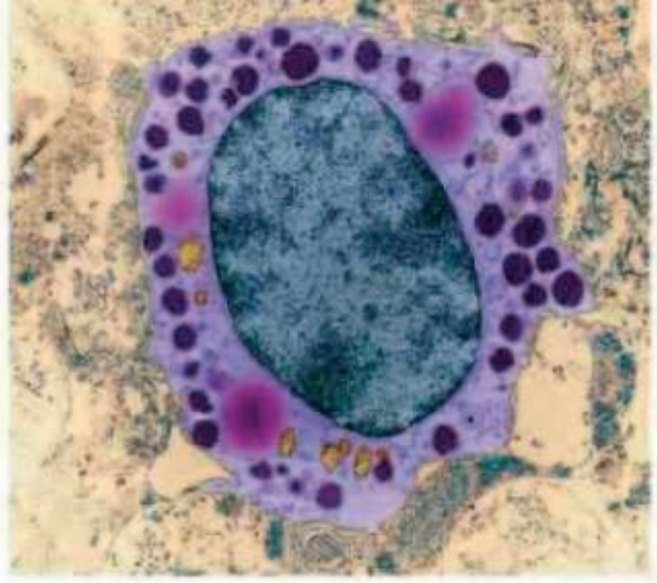
IMAGING TECHNIQUES

Imaging is vital to diagnose illness, unravel disease processes, and evaluate treatments. Modern techniques provide detailed information with minimum discomfort to the patient and have largely replaced surgery in establishing the presence and extent of disease. Imaging has also helped advance biological research.

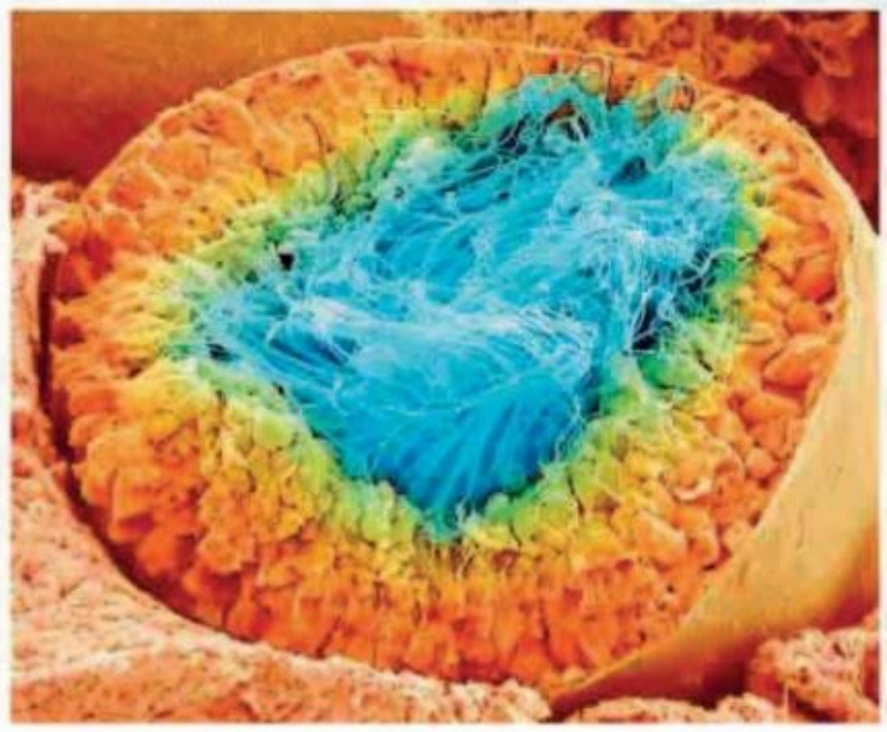


TEM of mast cell
Magnifications of several million times are possible using transmission electron microscopy (TEM). This image shows a mast cell with granules (dark purple) that it releases when it is damaged or is fighting microbes.

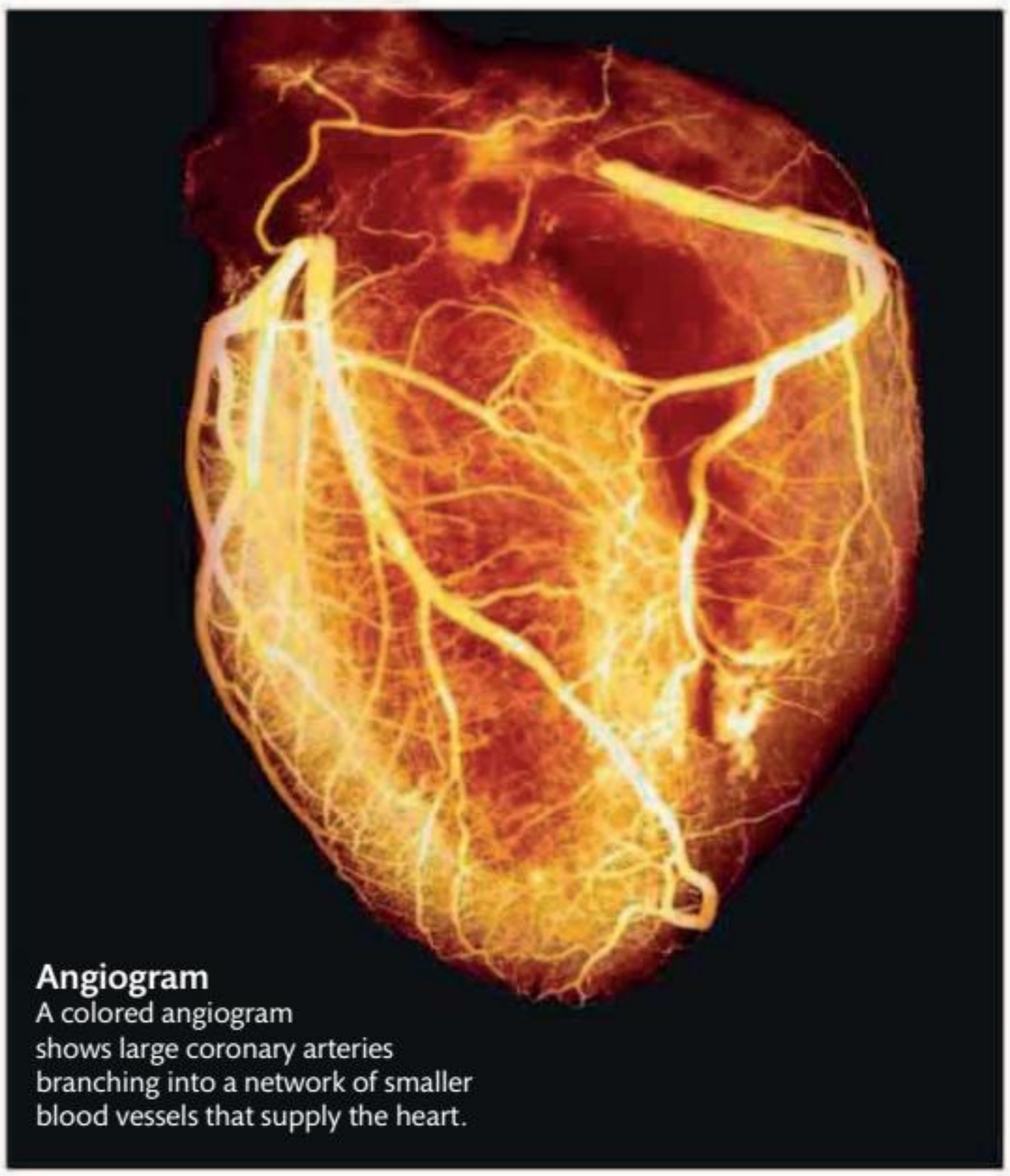
The invention of the X-ray in 1895 made the development of noninvasive medicine possible. Without the ability to see inside the body, many internal disorders could only be found after major surgery. Computerized imaging now helps doctors make early diagnoses, which at times greatly increase the likelihood of recovery. Computers process and enhance raw data to aid our visual ability. However, sometimes direct observation is essential. Viewing techniques have also become less invasive with the development of instruments such as the endoscope (see opposite).

MICROSCOPY

Light microscopy (LM) uses magnifying lenses to focus light rays. The light passes through a thin section of material and enlarges it up to 2,000 times. Higher magnifications are achieved with beams of electrons (subatomic particles). In scanning electron microscopy (SEM), the beam runs across a specimen coated with gold film and bounces off the surface to create a three-dimensional image.



SEM of seminiferous tubule
This freeze-fracture image—in which the specimen is frozen and then cracked open before being scanned—shows sperm heads buried in Sertoli cells (orange) with the tails (blue) projecting into the tubule's lumen.



Angiogram
A colored angiogram shows large coronary arteries branching into a network of smaller blood vessels that supply the heart.

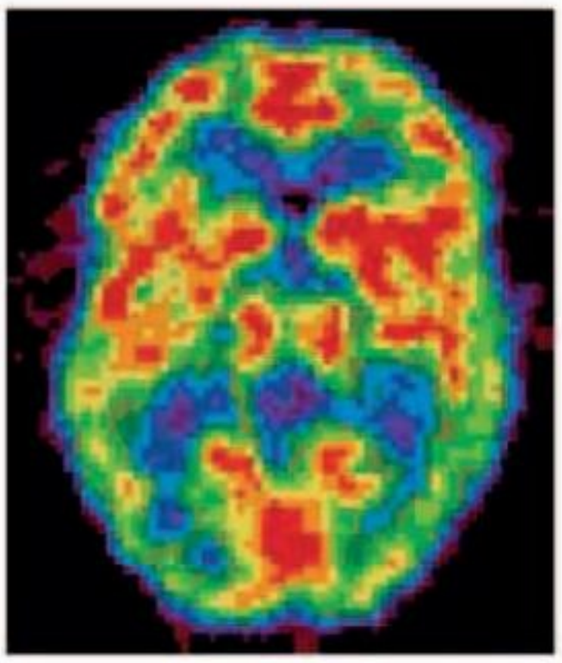
X-RAY

Like light rays, X-rays are electromagnetic energy, but of short wavelength. When passed through the body to strike photographic film, they create shadow images (radiographs). Dense structures, such as bone, absorb more X-rays and show up as white, while soft tissues, such as muscle, appear gray. Air-filled spaces, such as the lungs, appear black. The spaces inside the digestive tract, or within blood vessels, may be visualized by filling them with a contrast medium—such as iodine or barium—that absorbs X-rays. A contrast X-ray image of blood vessels is known as an angiogram.

X-ray of foot
This X-ray image shows the foot bones of an adult from above. X-rays are especially useful for viewing dense tissue, such as bone.

RADIONUCLIDE AND PET SCANNING

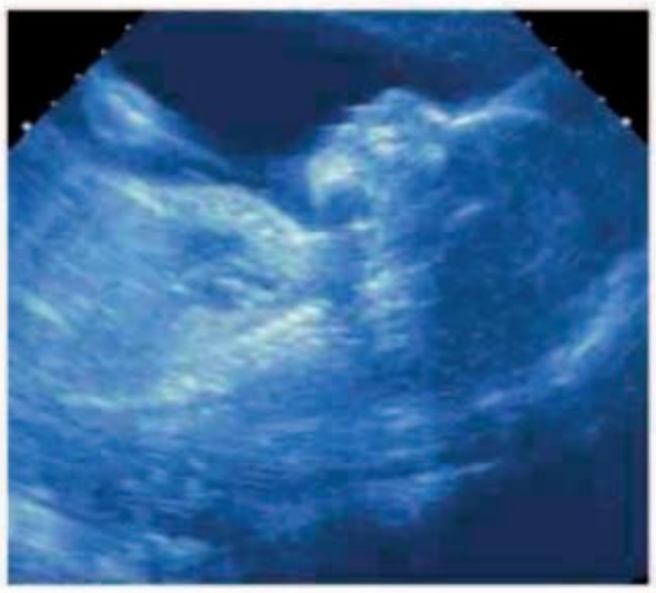
In radionuclide imaging, a radioactive substance is injected into the body and is absorbed by the area to be imaged. As the substance decays, it emits gamma rays, which a computer forms into an image. Positron emission tomography (PET) is a type of radionuclide scanning where the injected chemical emits radioactive particles called positrons. PET gives data about how the brain functions rather than anatomy.



PET brain scan
This scan of the brain shows that the organ is active even in sleep mode. Areas in red, orange, and yellow represent high levels of activity.

ULTRASOUND

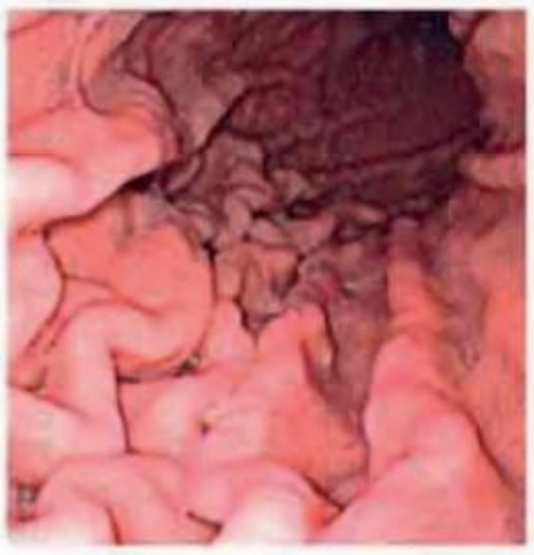
In ultrasound, a device called a transducer emits very high-frequency sound waves as it is passed over the body part being examined. The sound waves echo back to the device based on the density of the tissues they encounter. A computer analyses the reflected waves and creates an image.



Fetal ultrasound
Low-intensity ultrasound is a safe way to monitor fetal development. In this scan the fetus's head can be seen clearly in profile on the right.

ENDOSCOPY

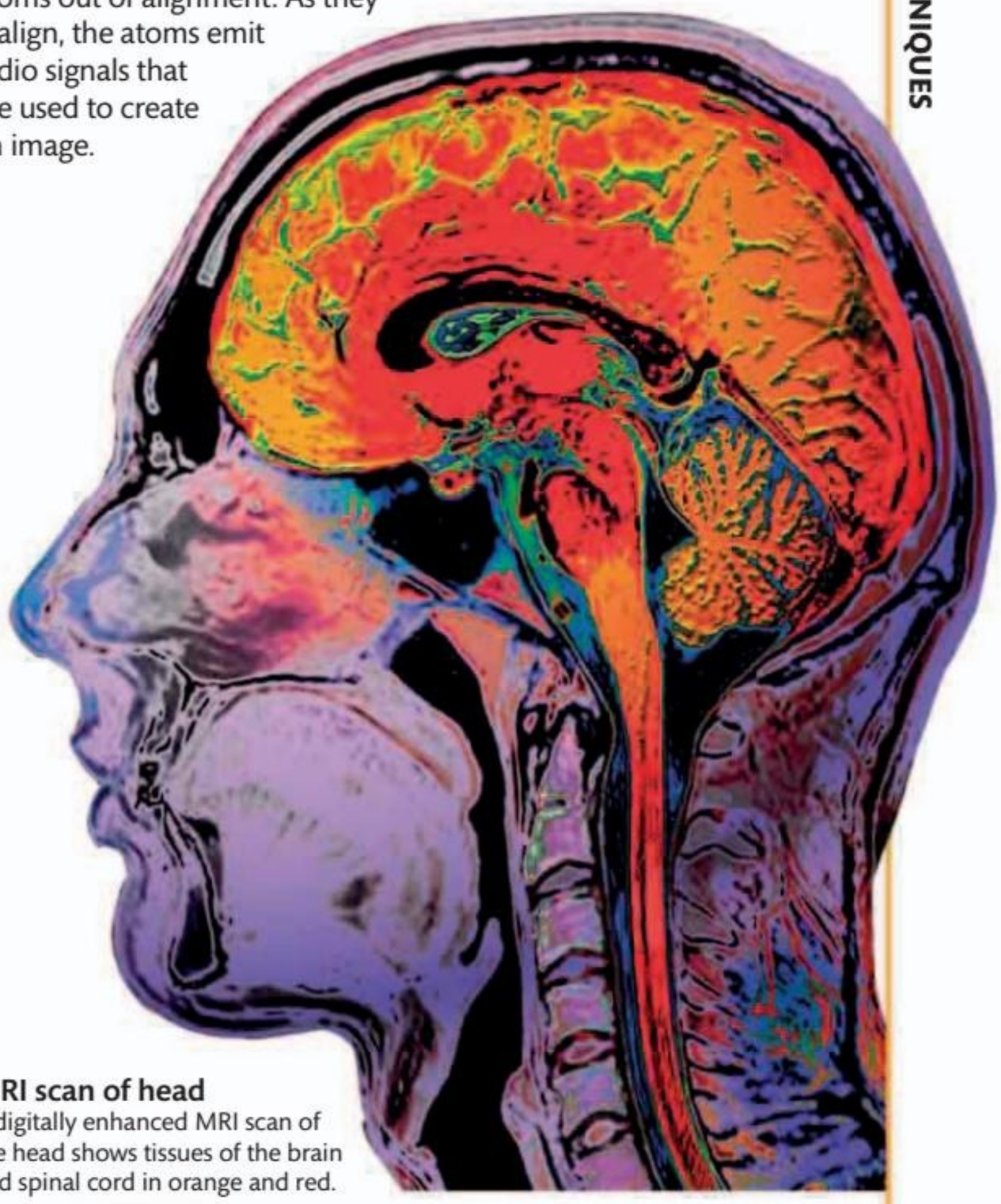
Telescopelike endoscopes are inserted through natural orifices or incisions to image the body's interior. They can be bent and controlled, and may carry instruments for other purposes as well, such as surgery and biopsy. Endoscopes have been designed to fit various body parts—bronchoscope for airways, gastroscope for the stomach, laparoscope for abdomen, and proctoscope for lower bowel.



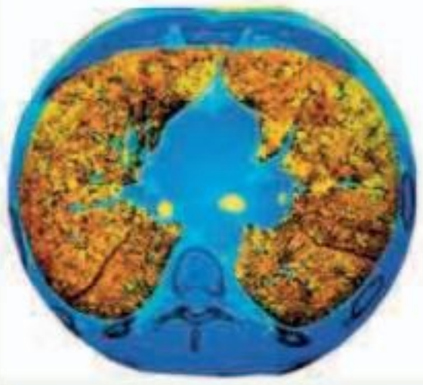
Endoscopic view of stomach
The gastric mucosa (inner lining) of a healthy stomach as seen through an endoscope. This procedure may be performed to investigate upper digestive tract disorders.

MRI AND CT SCANNING

Computerized tomography (CT) and magnetic resonance imaging (MRI) detail various tissue types. In CT, a scanner using X-rays rotates around the patient as a computer records the levels of electromagnetic energy passing through tissues of different densities. A cross section is built from layers of data. In MRI, a person lies in a magnetic chamber that causes hydrogen atoms in the body to align. A pulse of radiowaves is released, throwing the atoms out of alignment. As they realign, the atoms emit radio signals that are used to create an image.



MRI scan of head
A digitally enhanced MRI scan of the head shows tissues of the brain and spinal cord in orange and red.



CT scan of lungs
In a horizontal slice through the chest, the spongy tissues and airways of the healthy lungs (oranges and yellows) show up clearly. The heart and major blood vessels between the lungs are mid-blue; the vertebrae, ribs, and sternum are dark blue.

ELECTRICAL ACTIVITY

Monitoring electrical activity in the body can reveal whether it is functioning normally. Signals coming from muscles and nerves are detected by applying sensor pads to the skin. The signals are sent to a computer that coordinates, amplifies, and displays them as a real-time trace—usually a spiked or wavy line. Examples of this technique include electrocardiography (ECG) of the heart, electromyography (EMG) of skeletal muscles, and electroencephalography (EEG) of the brain's nerve activity.

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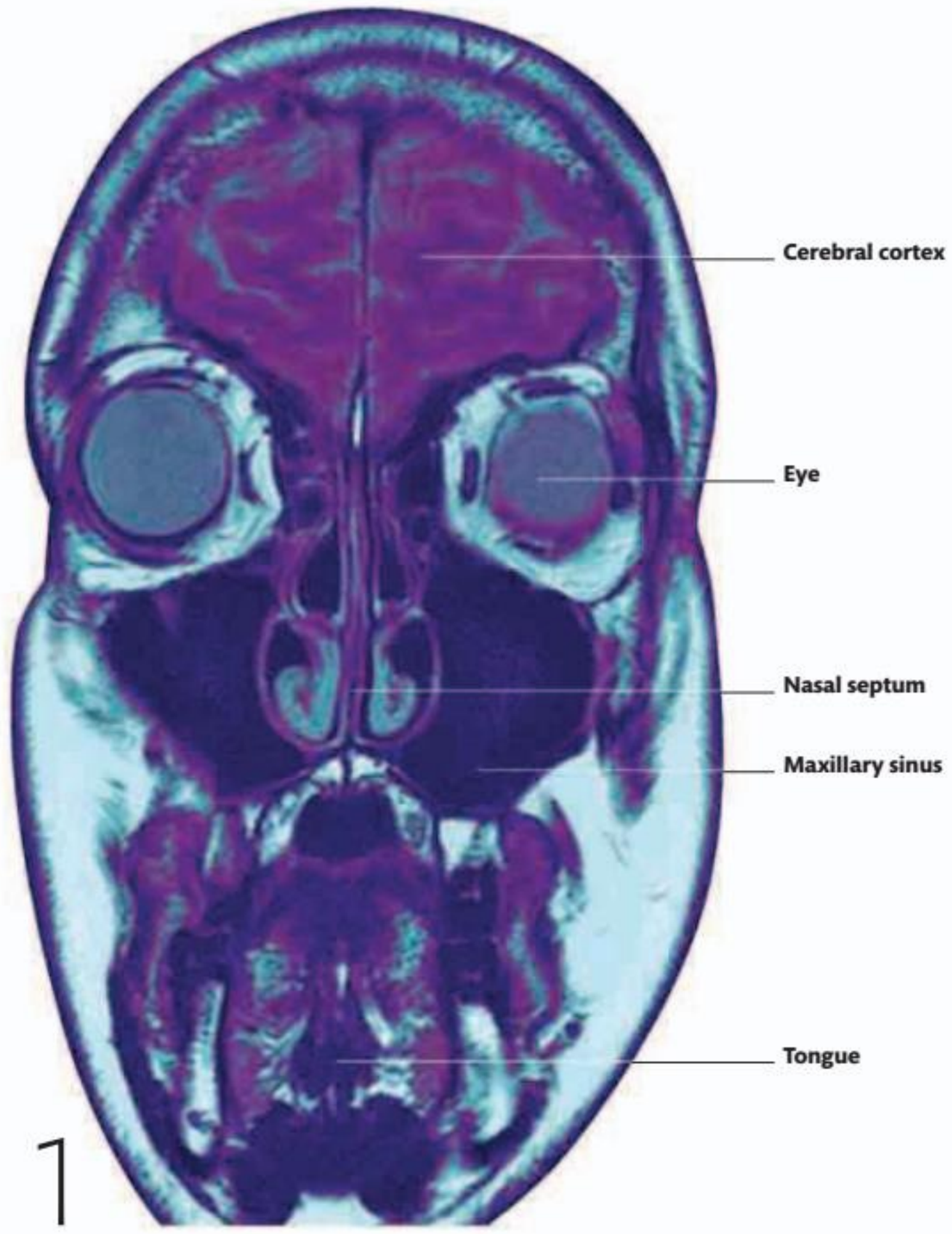
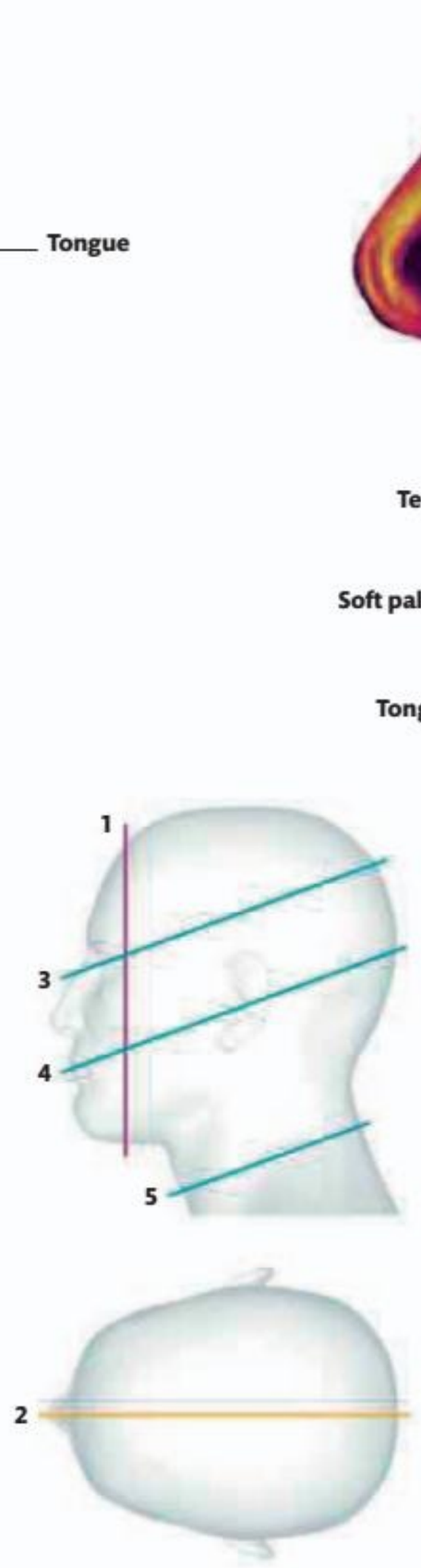


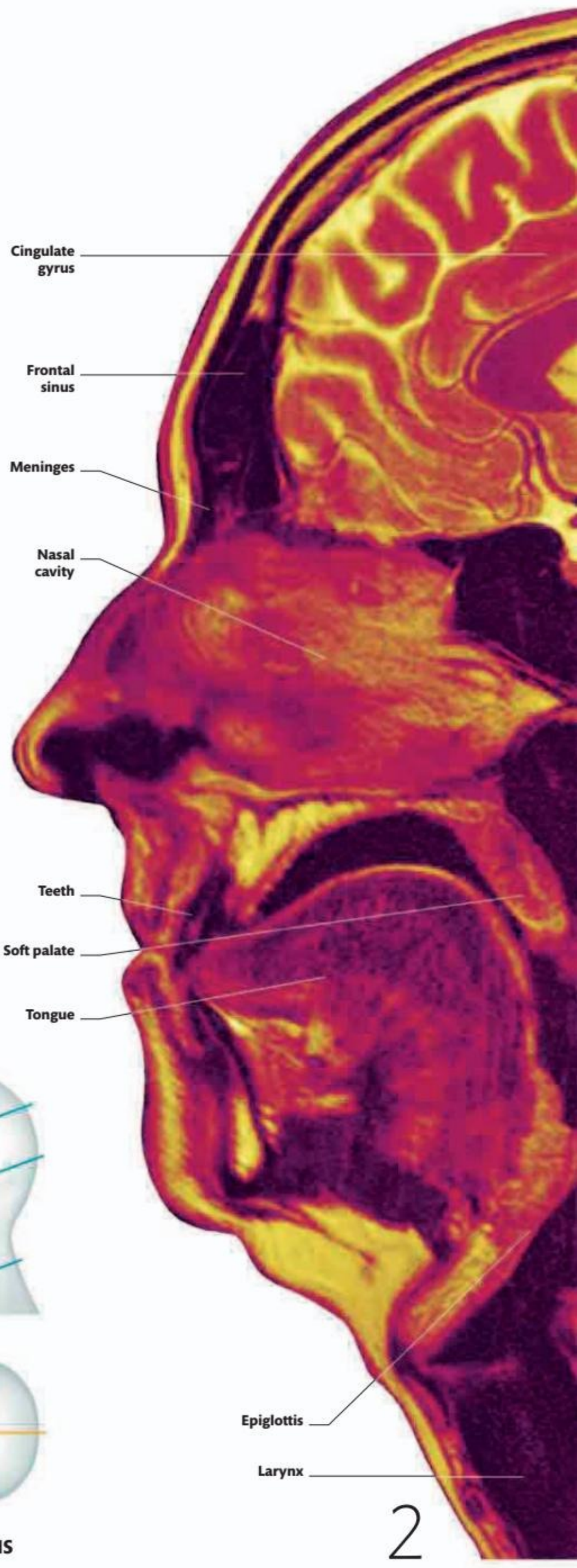
1

HEAD AND NECK

The discovery of X-rays at the end of the 19th century suddenly created the possibility of looking inside the human body—without having to physically cut it open. Medical imaging is now an important diagnostic tool, as well as being used for the study of normal anatomy and physiology. In computed tomography (CT), X-rays are used to produce virtual sections or slices through the body. Another form of sectional imaging, using magnetic fields rather than X-rays to create images, is magnetic resonance imaging (MRI), as shown here. MRI is very useful for looking in detail at soft tissue, for instance, muscle, tendons, and the brain. Also seen clearly in these sections are the eyes (1 and 3), the tongue (1 and 2), the larynx, vertebrae, and spinal cord (2 and 5).



LEVELS OF SCANS



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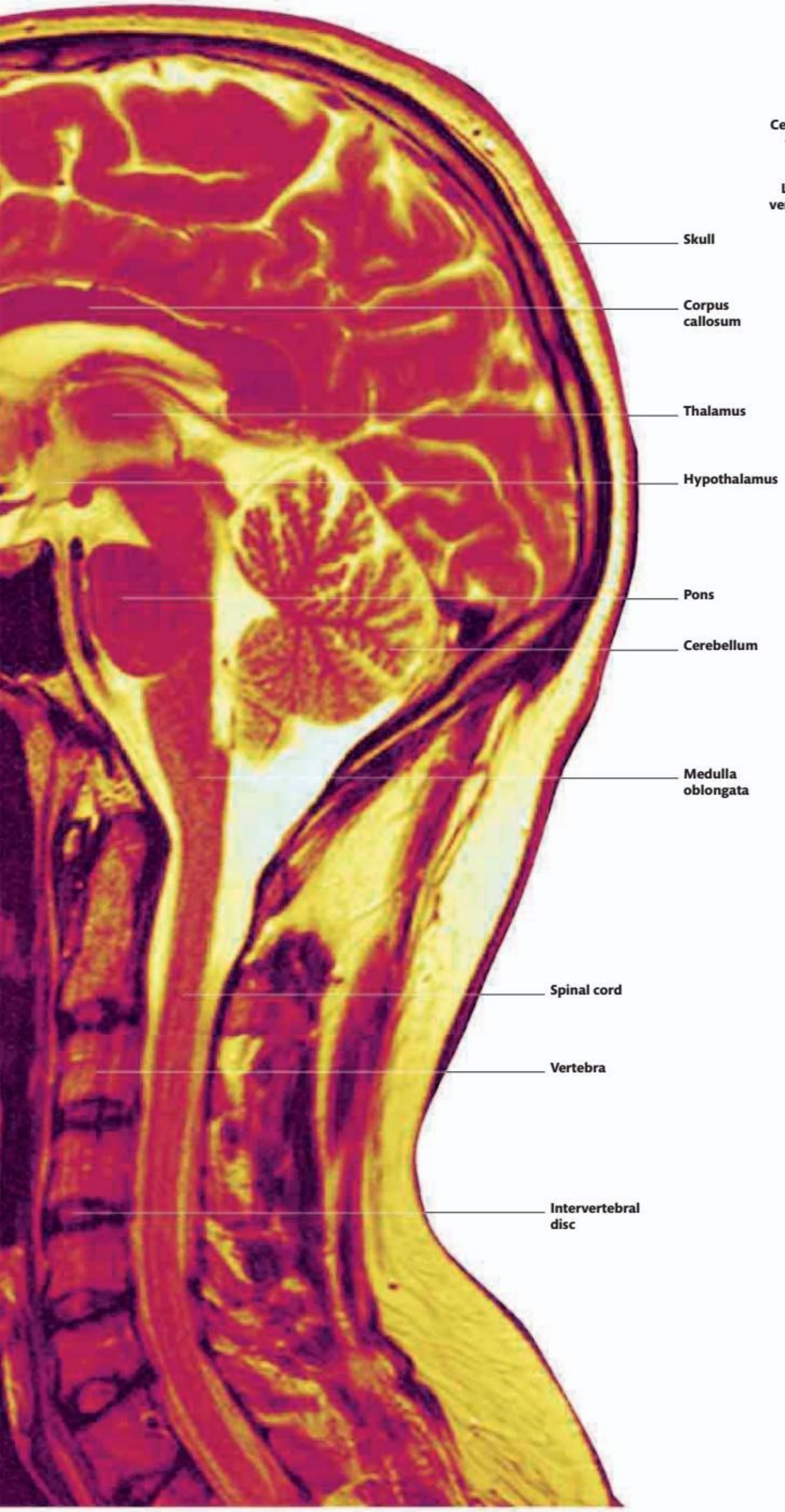

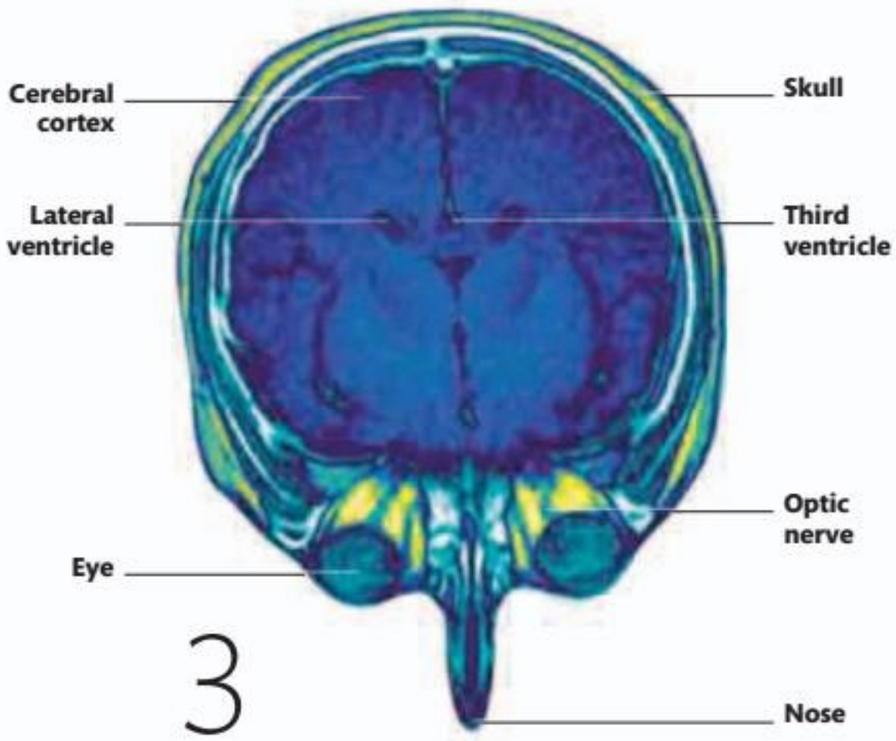

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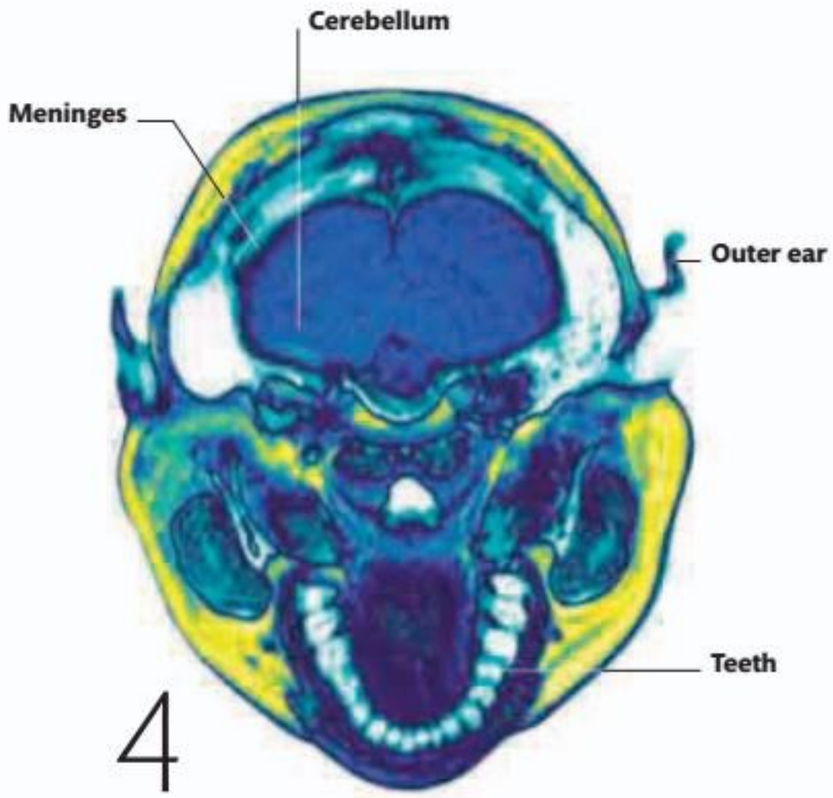

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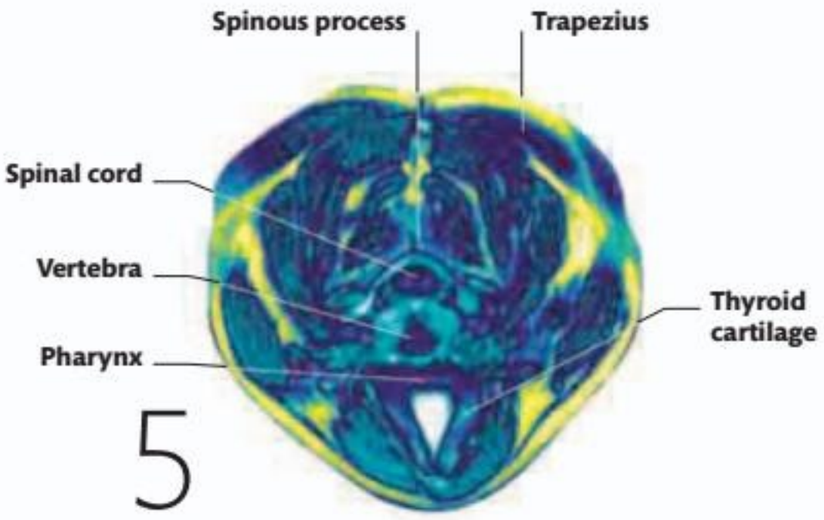

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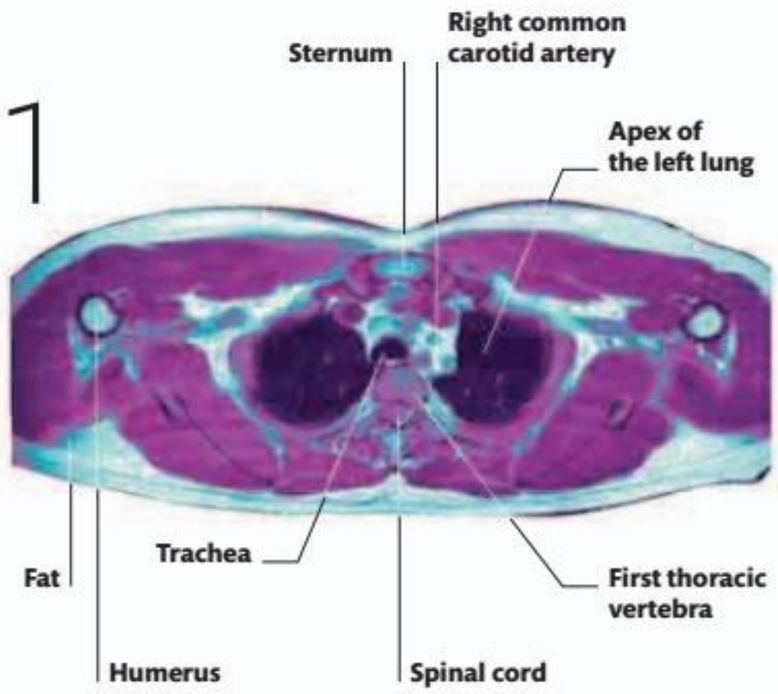
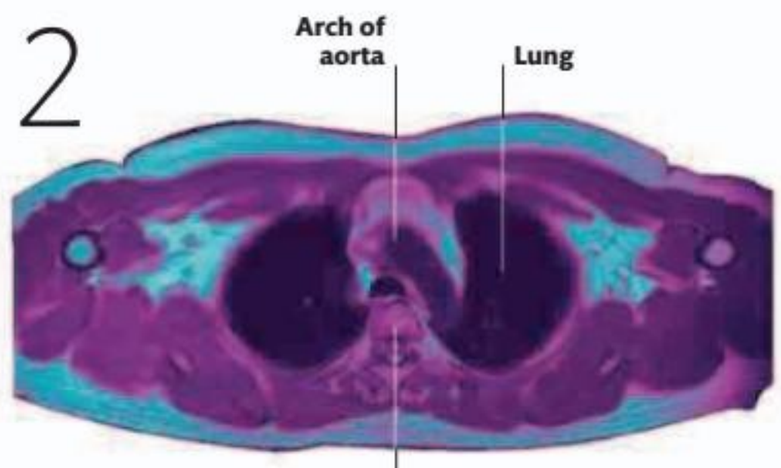
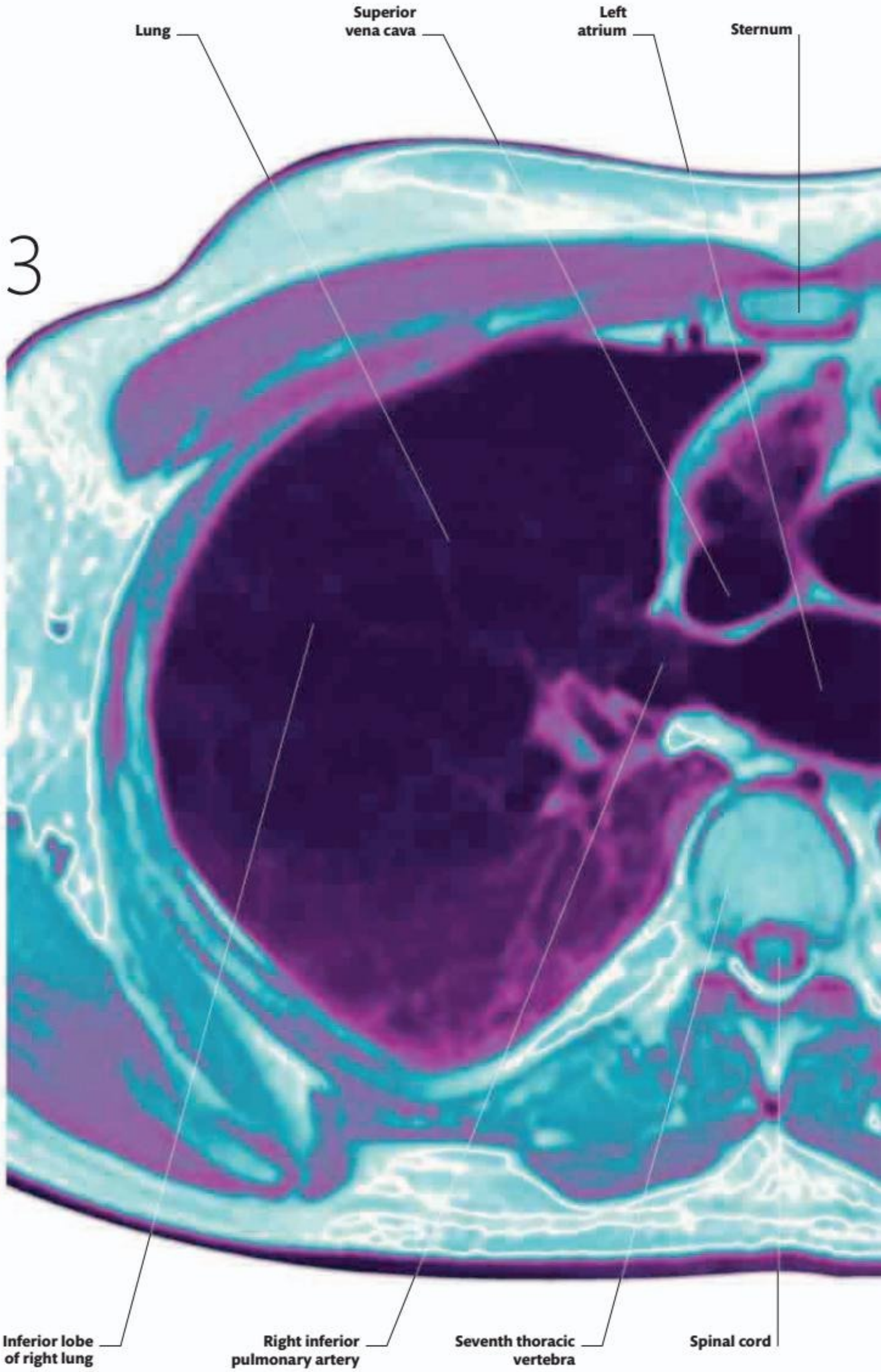
1


Sternum
Right common carotid artery
Apex of the left lung
Fat
Trachea
Humerus
Spinal cord
First thoracic vertebra

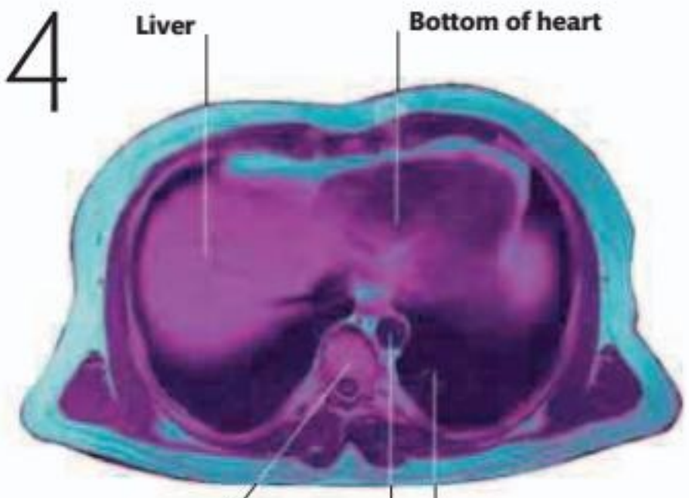
2

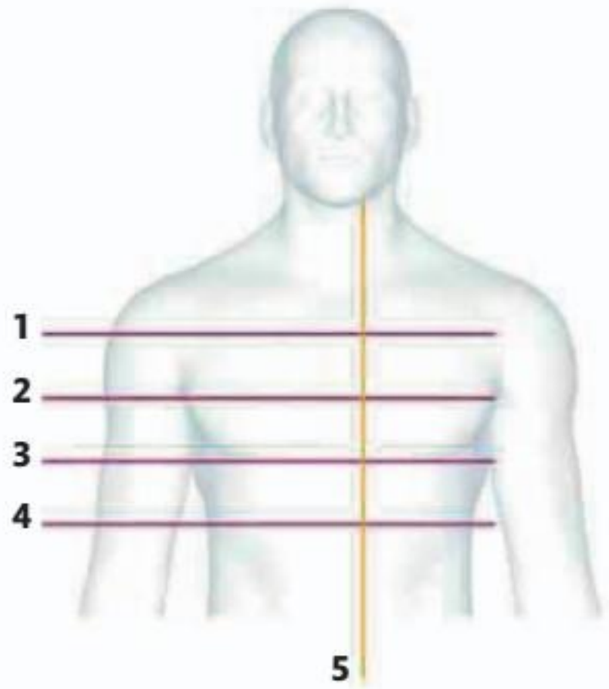

Arch of aorta
Lung
Fourth thoracic vertebra

3


Lung
Superior vena cava
Left atrium
Sternum
Inferior lobe of right lung
Right inferior pulmonary artery
Seventh thoracic vertebra
Spinal cord

4

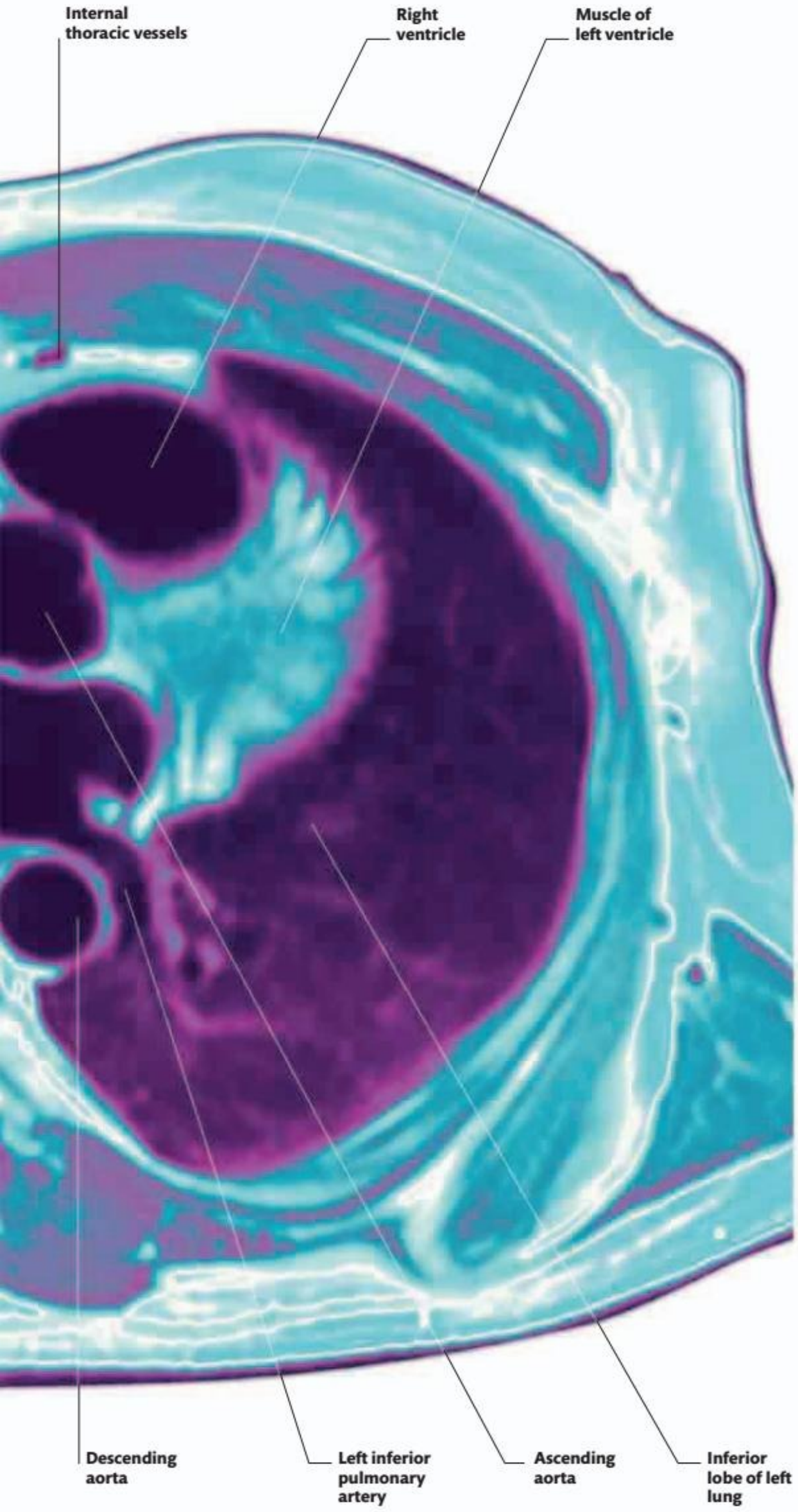

Liver
Bottom of heart
Tenth thoracic vertebra
Aorta
Inferior lobe of left lung

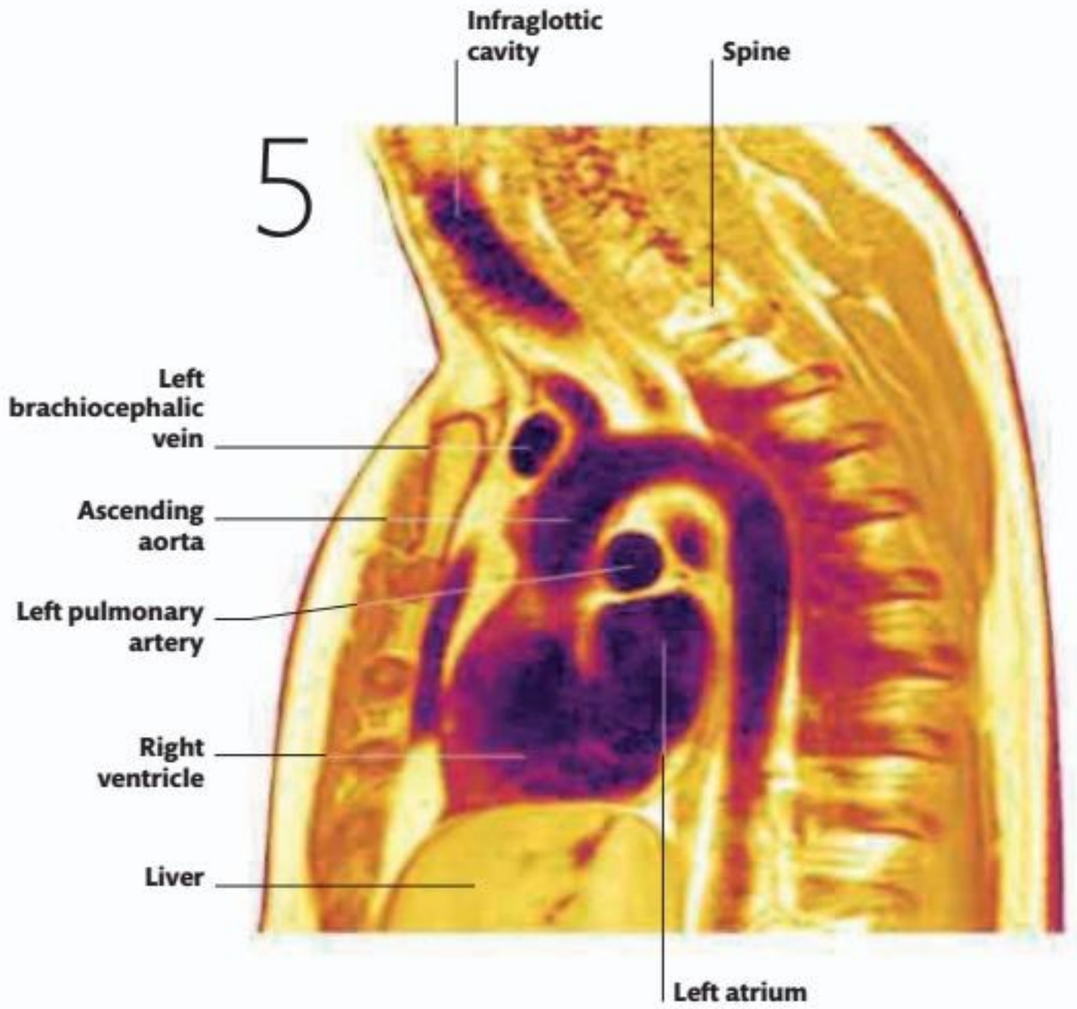


LEVELS OF SCANS

THORAX

The axial, or transverse, sections through the chest (sections 1–4) show the heart and large blood vessels lying centrally within the thorax, flanked by the lungs, and all set within the protective, bony casing of the ribcage. Section 1 shows the clavicles, or collarbones, joining the sternum at the front, the apex (top) of the lungs, and the great vessels passing between the neck and the thorax. Section 2 is lower down in the chest, just above the heart, while section 3 shows the heart with detail of its different chambers. The aorta appears to be to the right of the spine in this image, rather than to the left, but this is the usual way in which scans are viewed. You need to imagine yourself standing at the foot of the bed, looking down at the patient. This means that the left side of the body appears on the right side of the image as you view it. Section 4 shows the very bottom of the heart, and the inferior lobes of the lungs.





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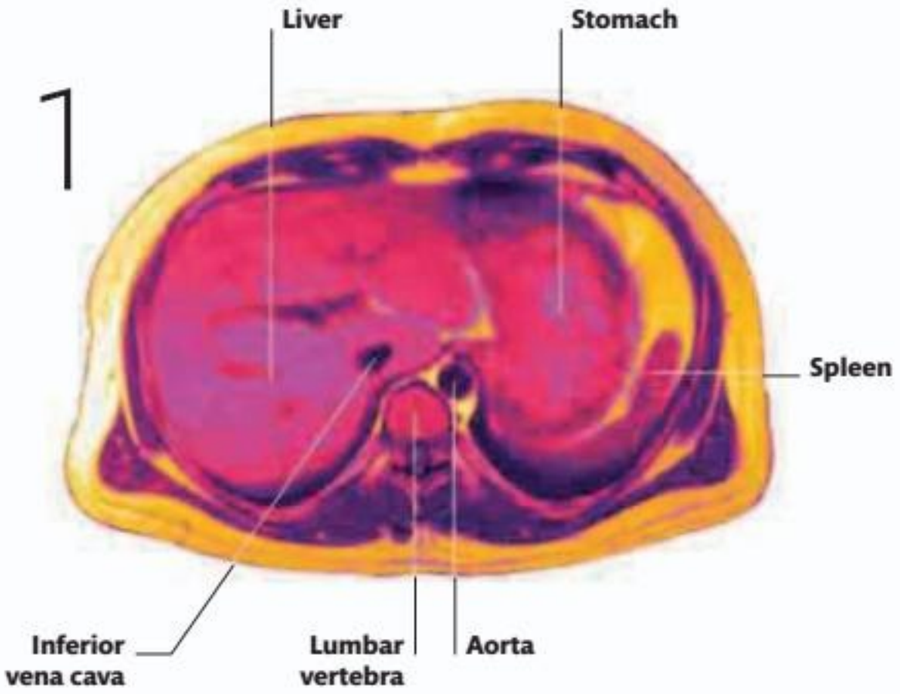
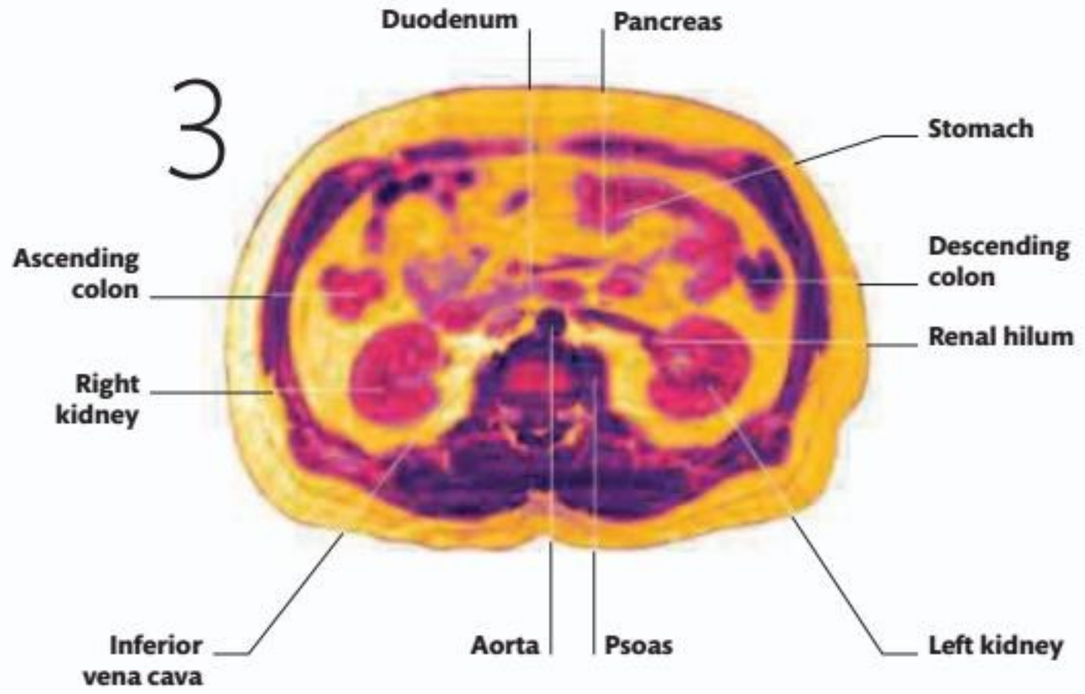
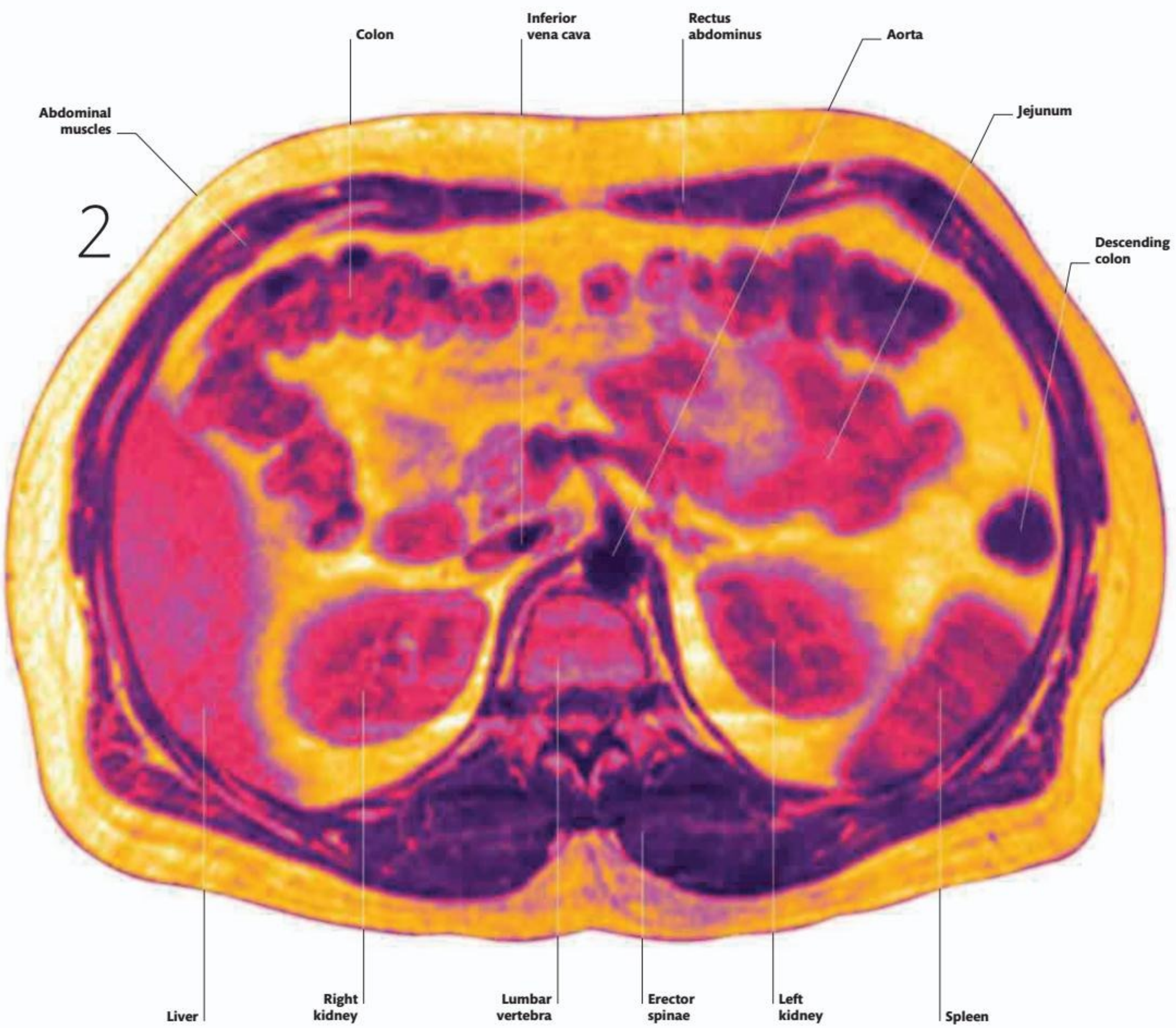
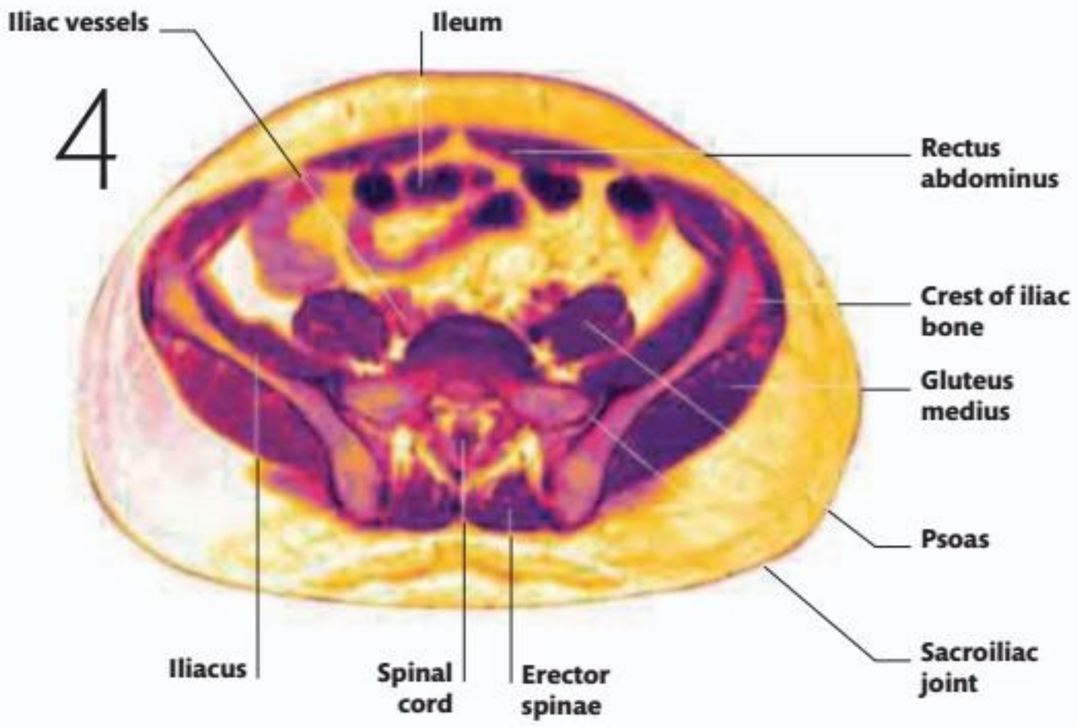

Liver
Stomach
Spleen
Inferior vena cava
Lumbar vertebra
Aorta

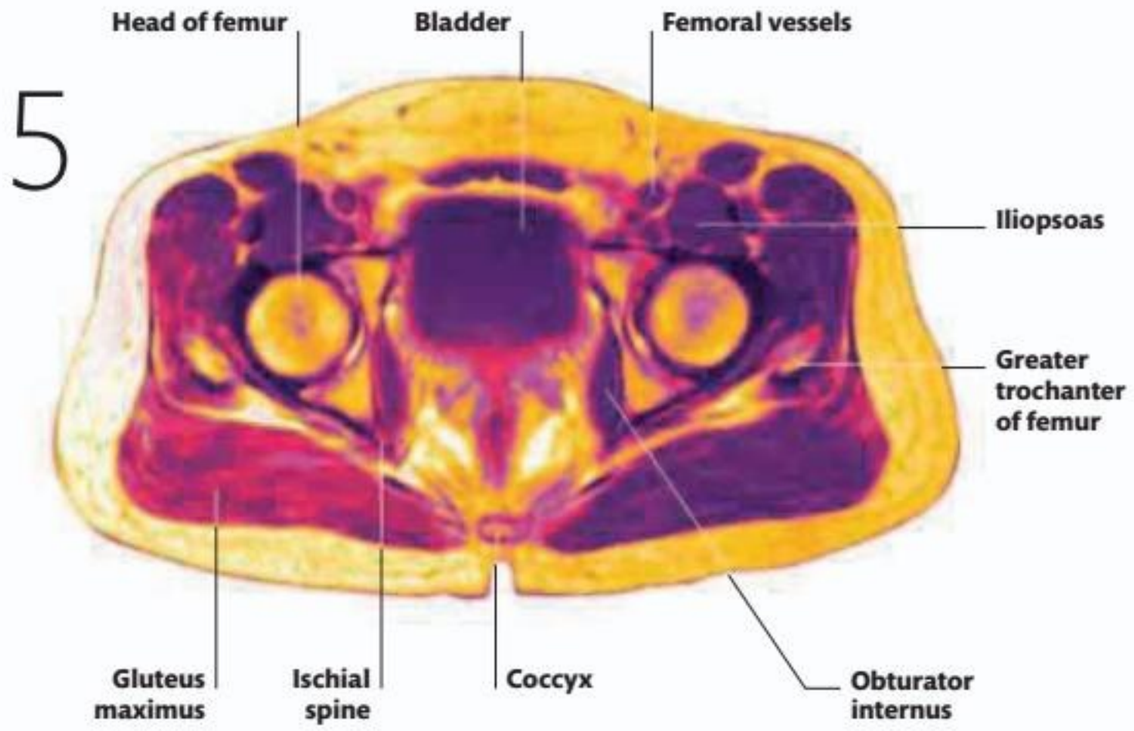
3


Duodenum
Pancreas
Stomach
Ascending colon
Descending colon
Renal hilum
Right kidney
Inferior vena cava
Aorta
Psoas
Left kidney

2

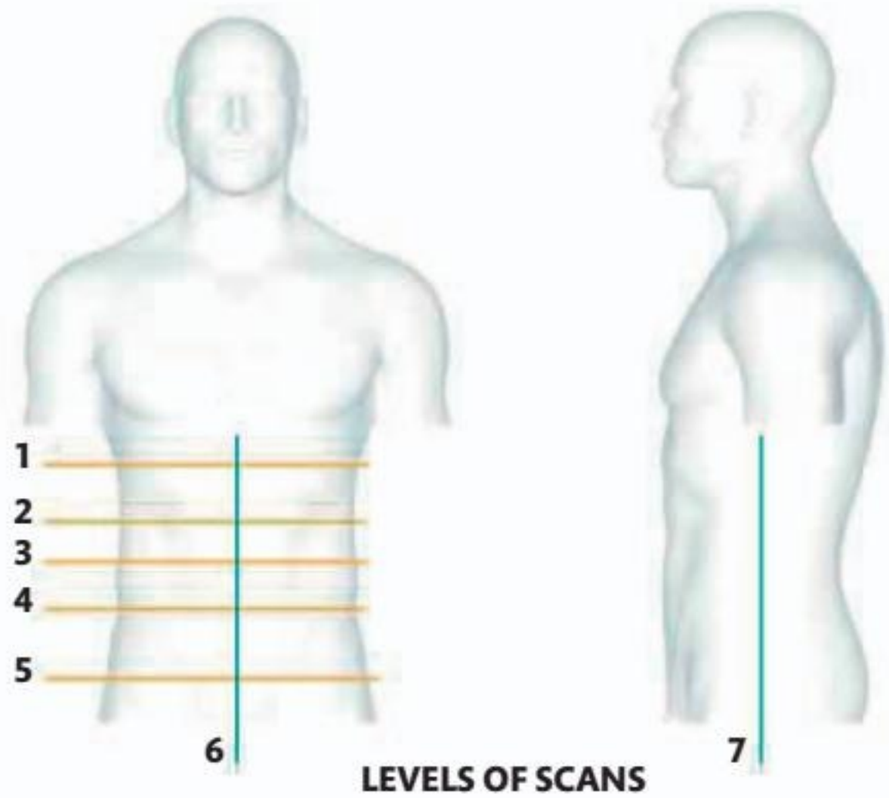

Colon
Inferior vena cava
Rectus abdominus
Aorta
Abdominal muscles
Jejunum
Descending colon
Liver
Right kidney
Lumbar vertebra
Erector spinae
Left kidney
Spleen



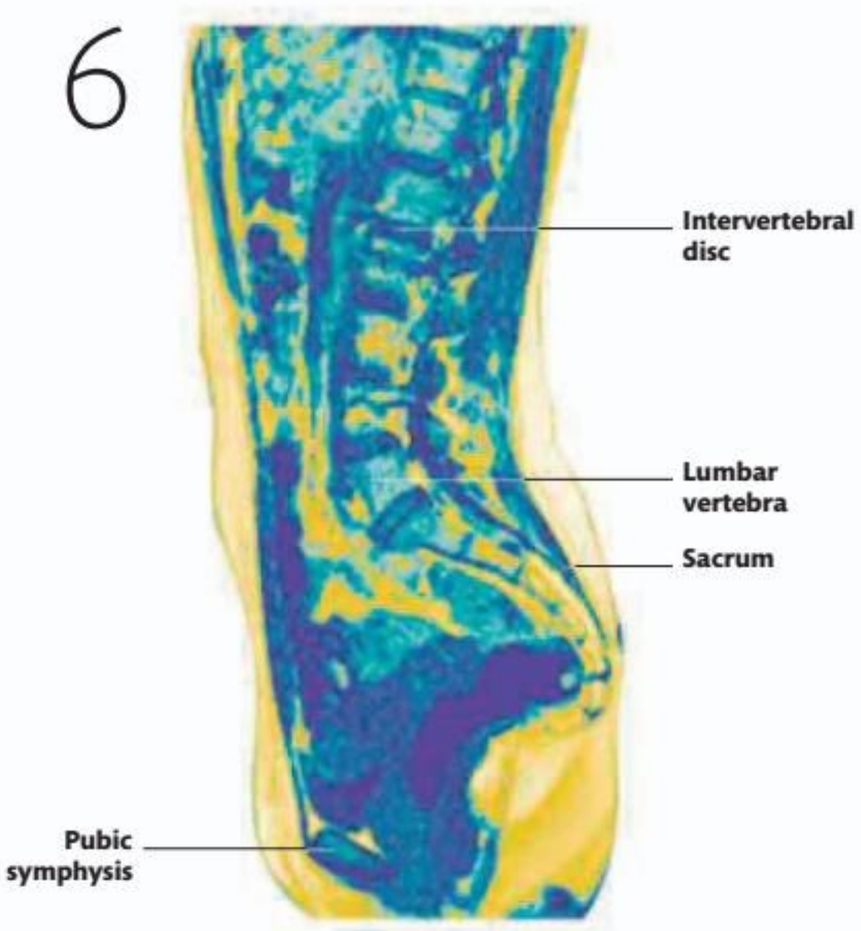


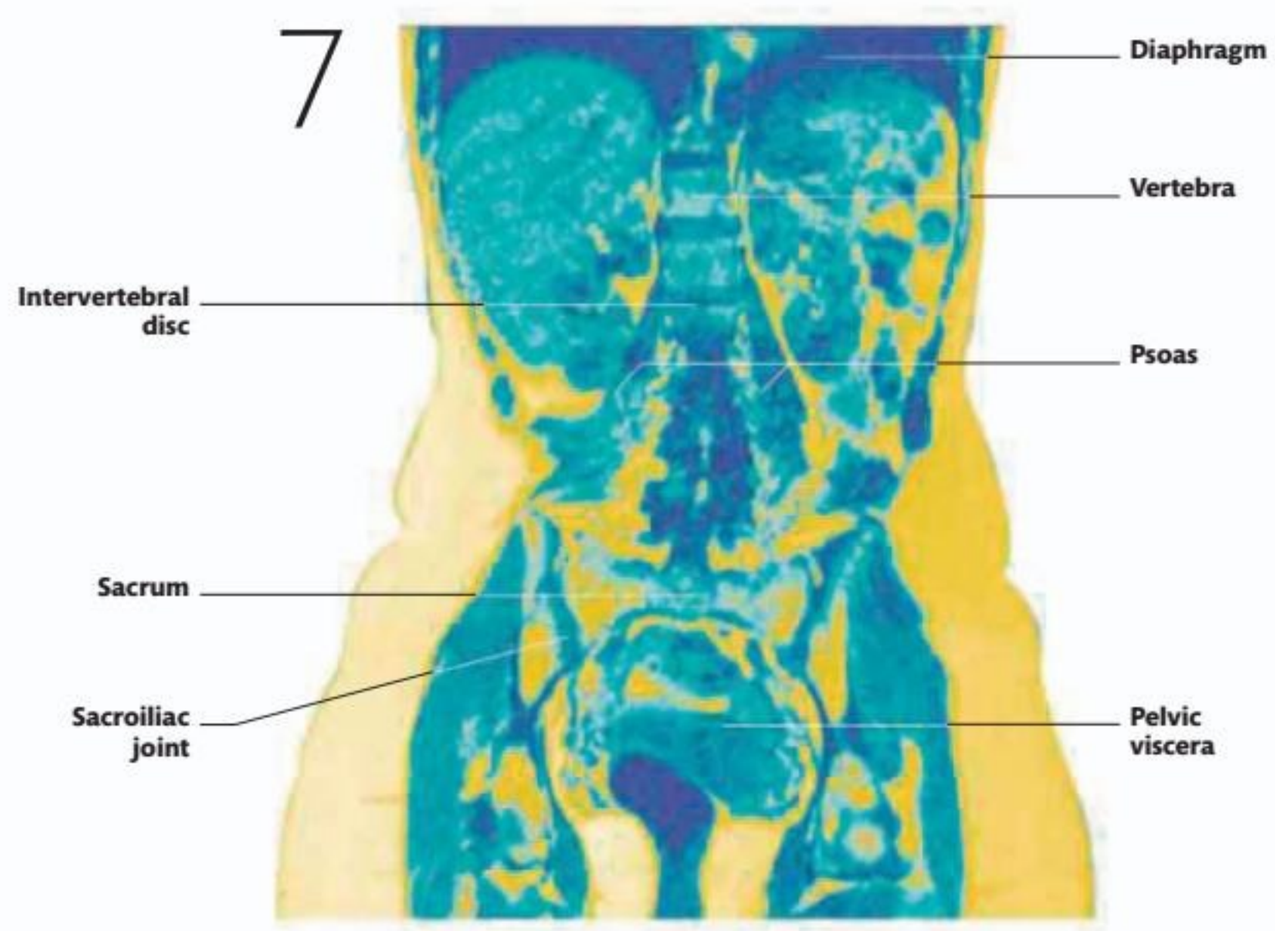
ABDOMEN AND PELVIS

MRI is a useful way of looking at soft tissues—and for visualizing the organs of the abdomen and pelvis, which only appear as subtle shadows on a standard X-ray. In the series of axial or transverse sections through the abdomen and pelvis, we can clearly see the dense liver, and blood vessels branching within it (section 1); the right kidney lying close to the liver, and the left kidney close to the spleen (section 2); the kidneys at the level where the renal arteries enter them (section 3), with the stomach and pancreas lying in front; coils of small intestine, the ileum, resting in the lower part of the abdomen, cradled by the iliac bones (section 4); and the organs of the pelvis at the level of the hip joints (section 5). The sagittal view (section 6) shows how surprisingly shallow the abdominal cavity is, in front of the lumbar spine. In a slim person, it is possible to press down on the lower abdomen and feel the pulsations of the descending aorta—right at the back of the abdomen.



LEVELS OF SCANS





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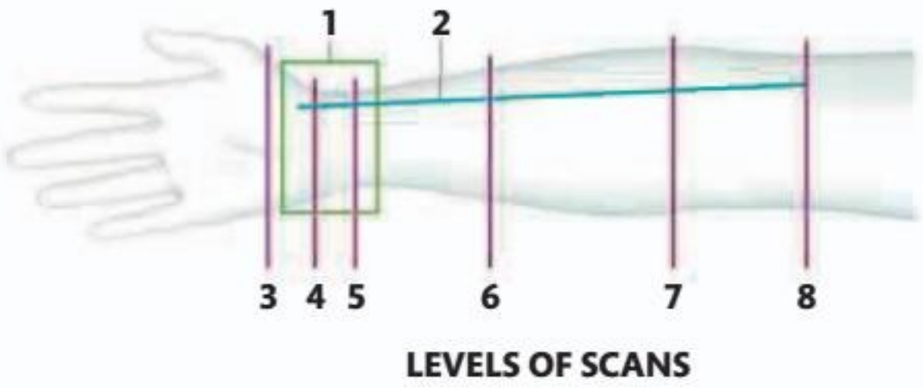
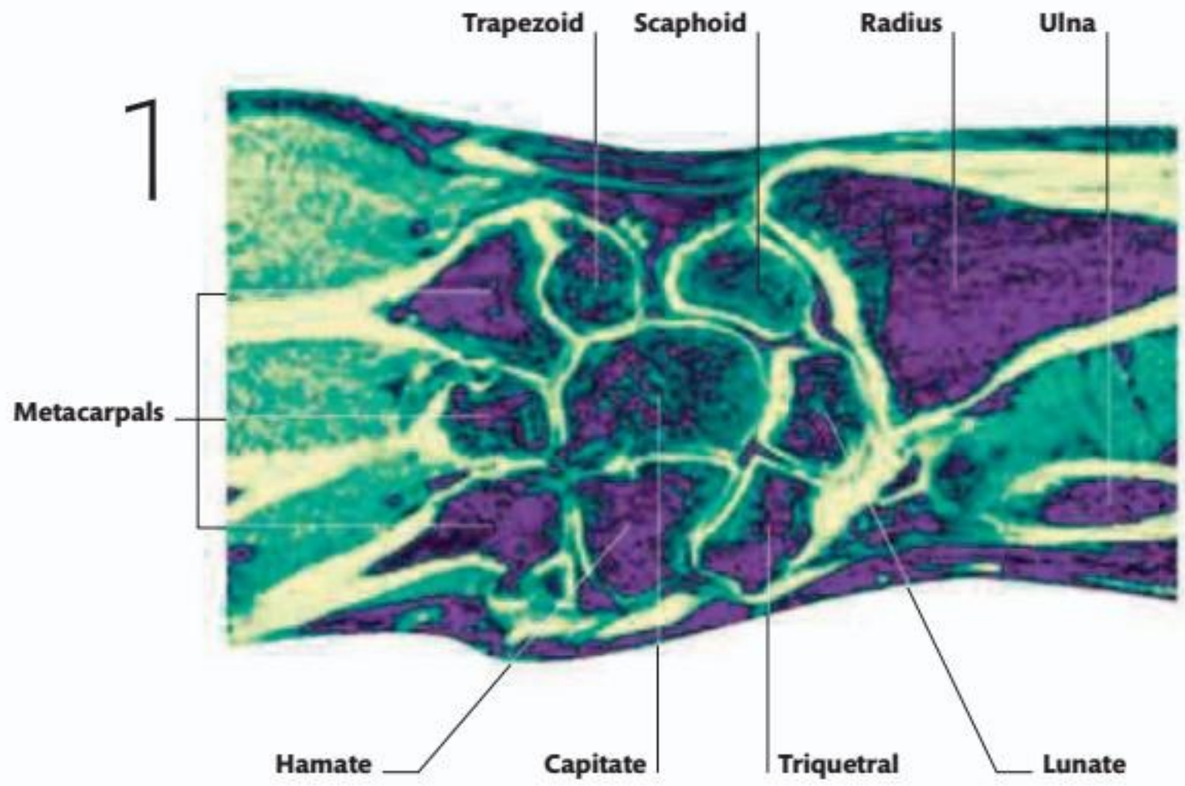
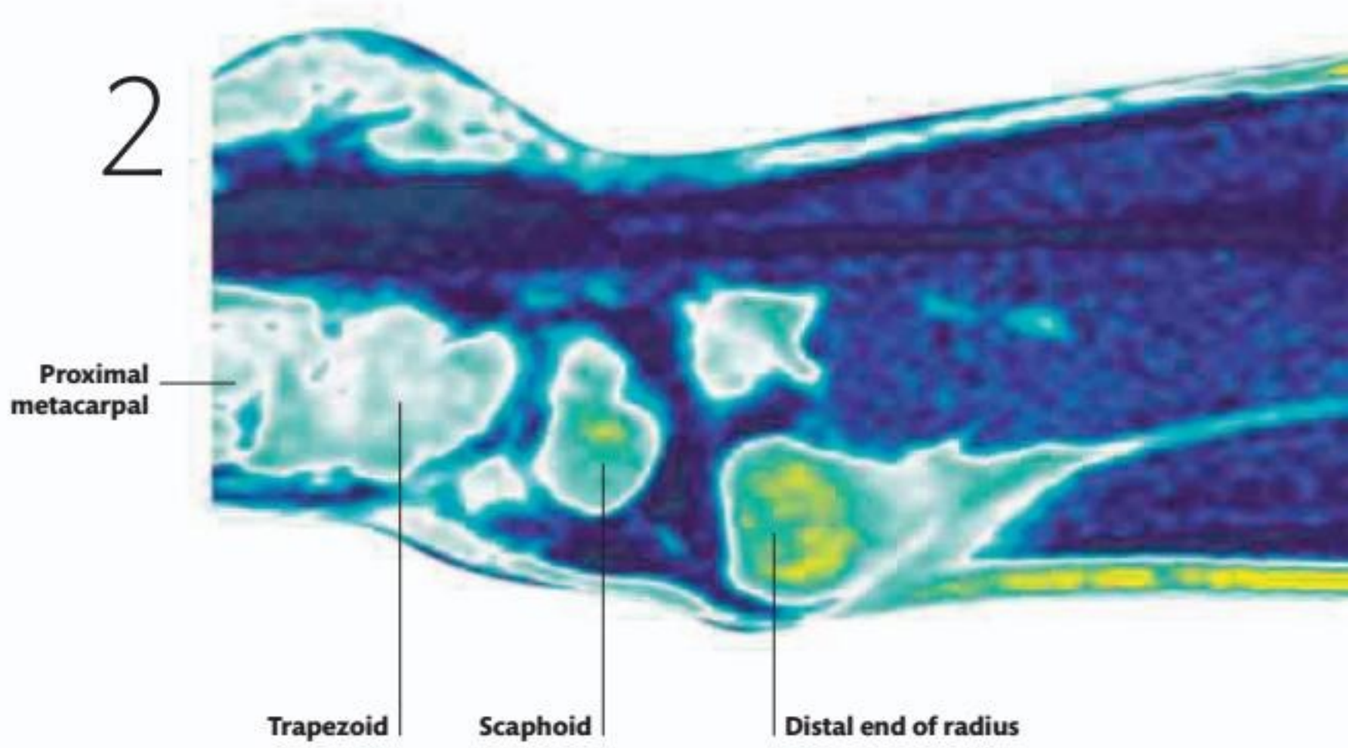


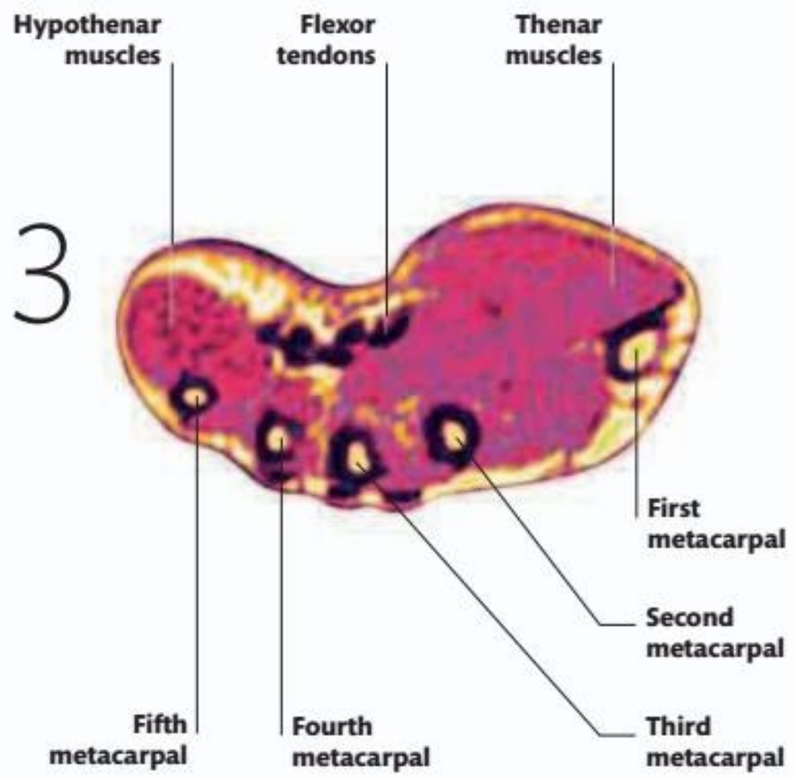
LEVELS OF SCANS

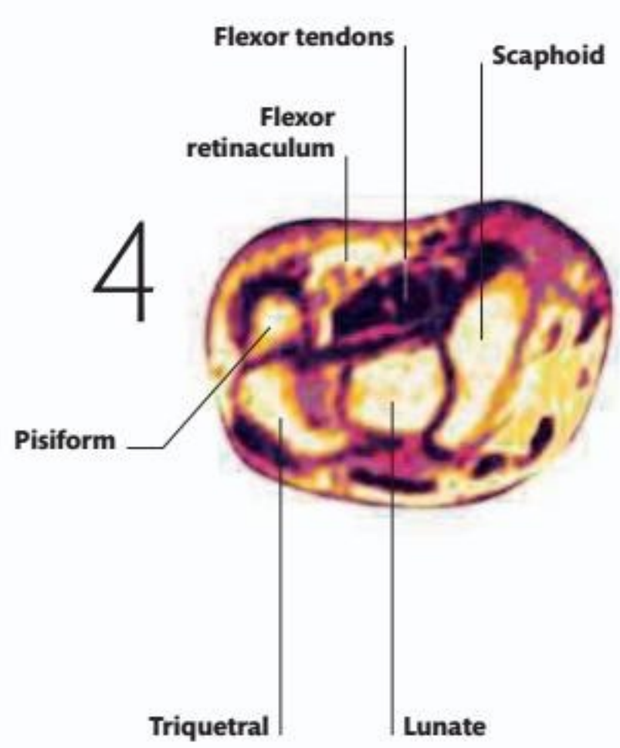
LOWER ARM AND HAND

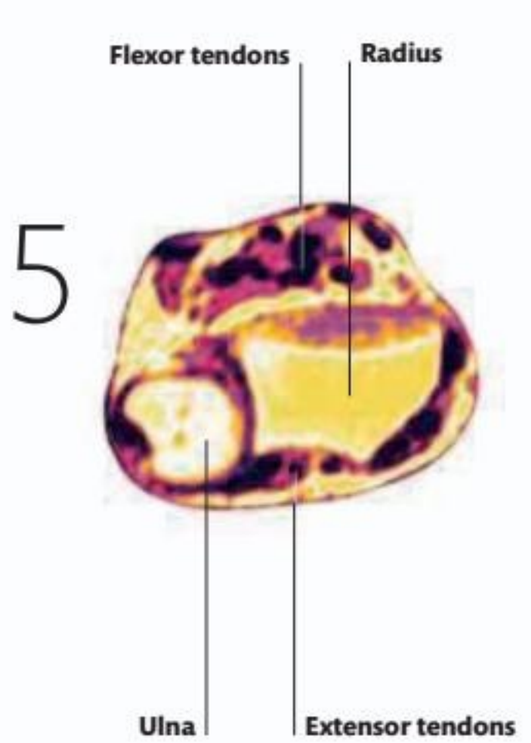
These scans of the arm, forearm, and hand show how tightly packed the structures are. Section 1 reveals the bones of the wrist—the carpals—interlocking like a jigsaw. The wrist joint itself is the articulation between the radius and the scaphoid and lunate bones. In section 2, part of the elbow joint is visible, with the bowl-shaped head of the radius cupping the rounded end of the humerus. Muscles in the forearm are grouped into two sets, flexors on the front and extensors behind the forearm bones and interosseous membrane. Compare sections 3–8 with sections through the leg (see pp.234–35)—both limbs have a single bone (humerus or femur) in the upper part, two bones in the lower part (radius and ulna in the forearm; tibia and fibula in the lower leg), a set of bones in the wrist and ankle (carpals and tarsals), fanning out to five digits at the end of the limb. Evolutionarily, these elements developed from the rays of a fish fin.

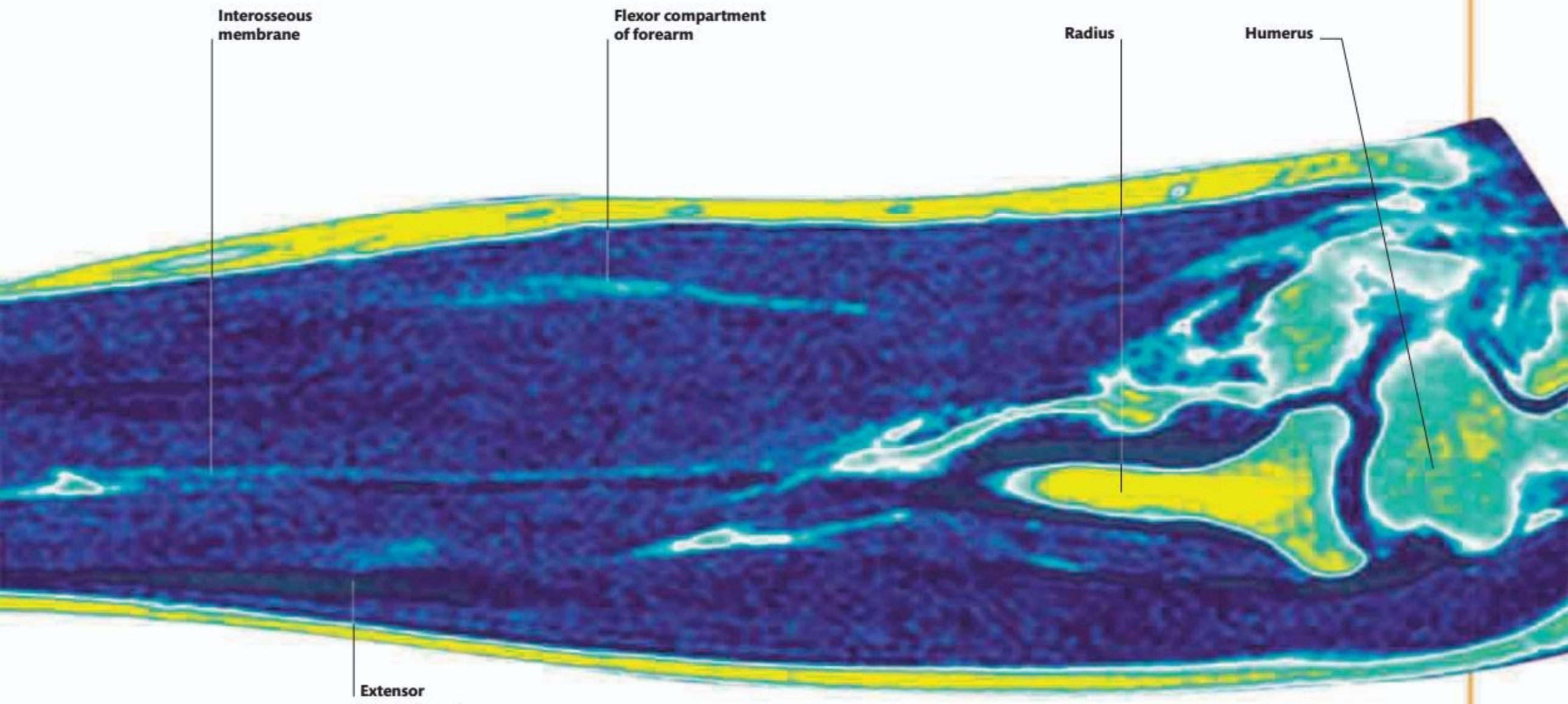












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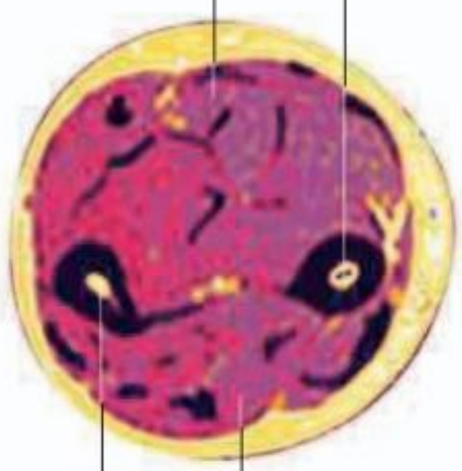

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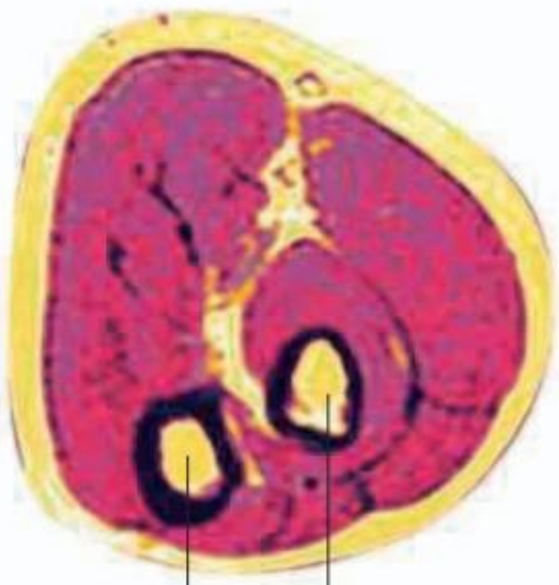

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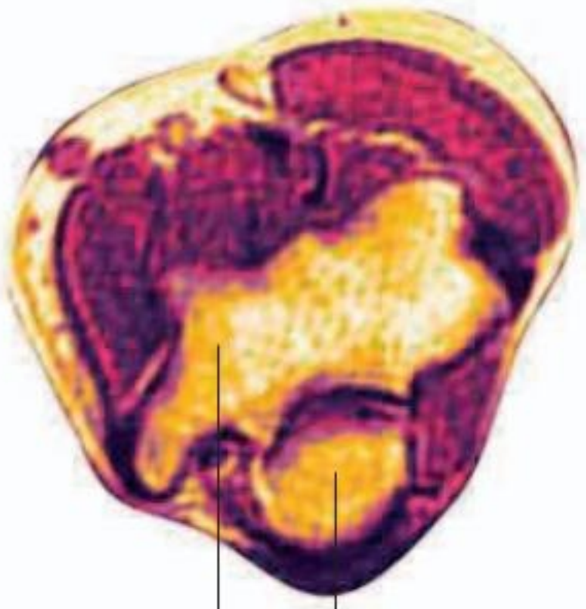

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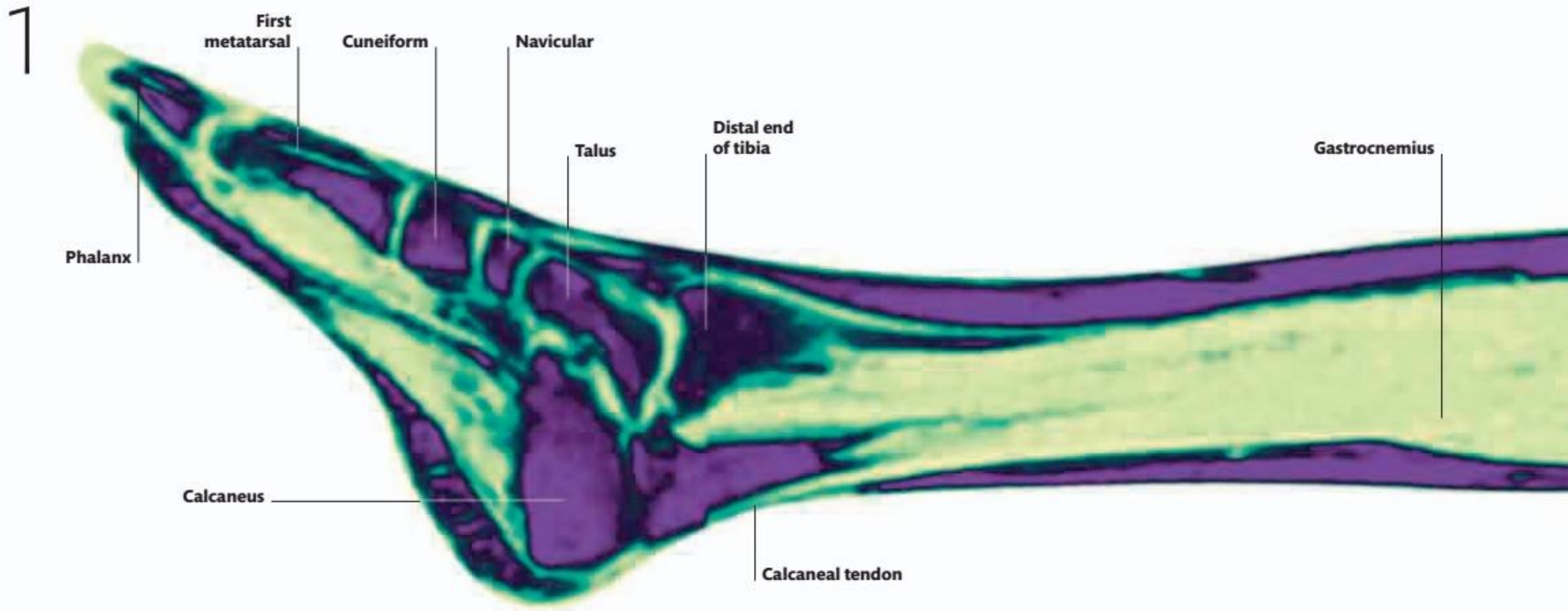
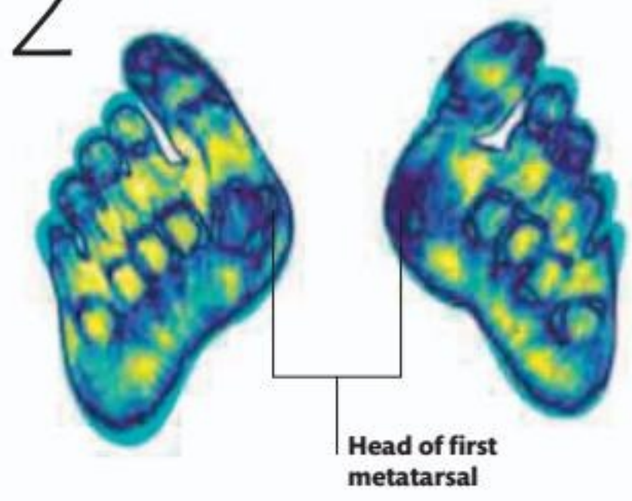
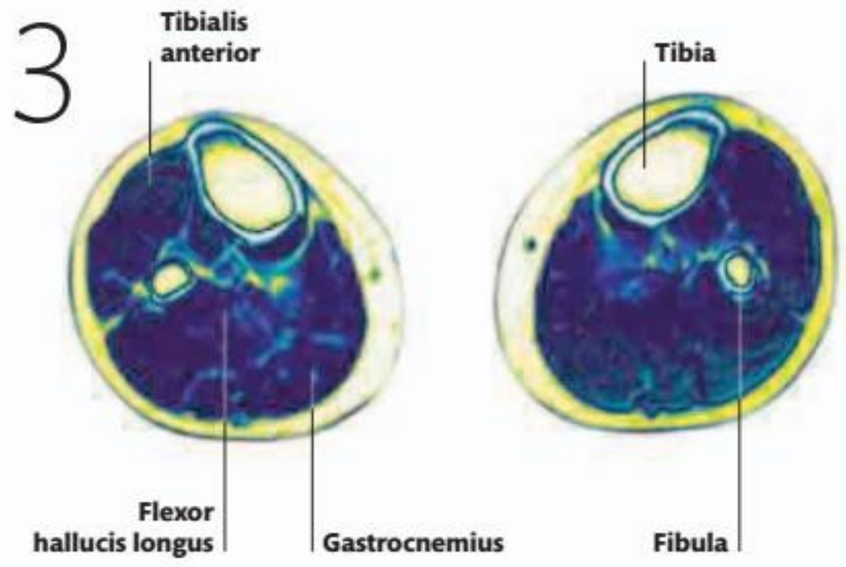
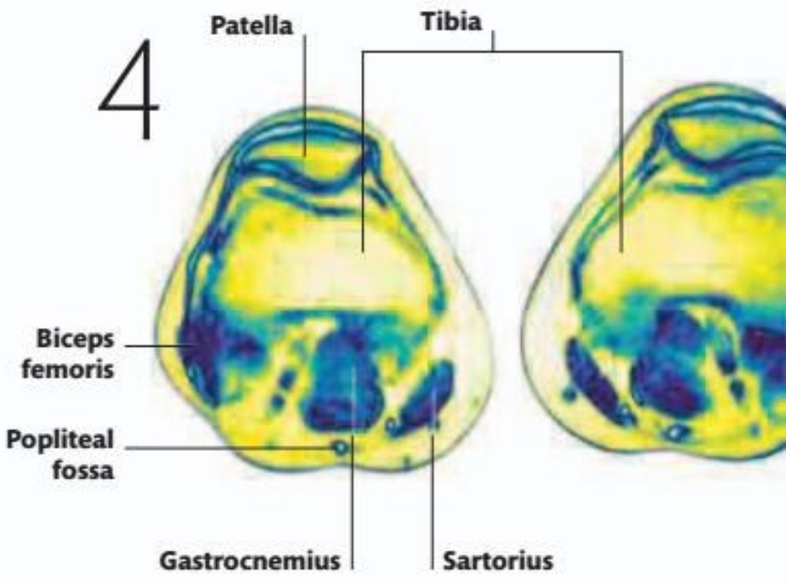


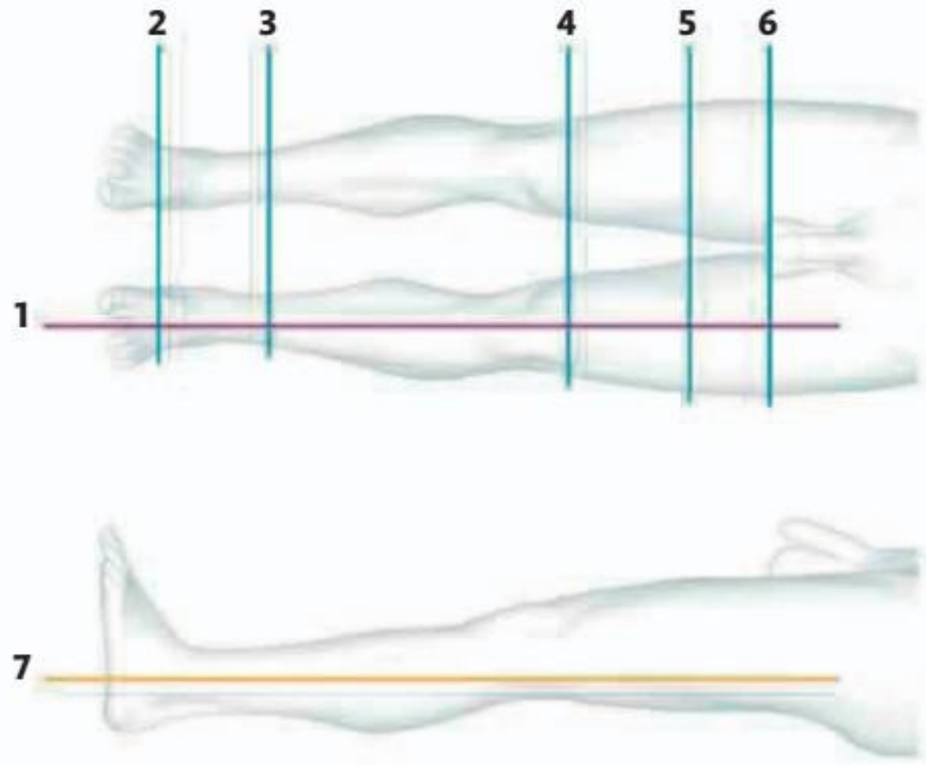




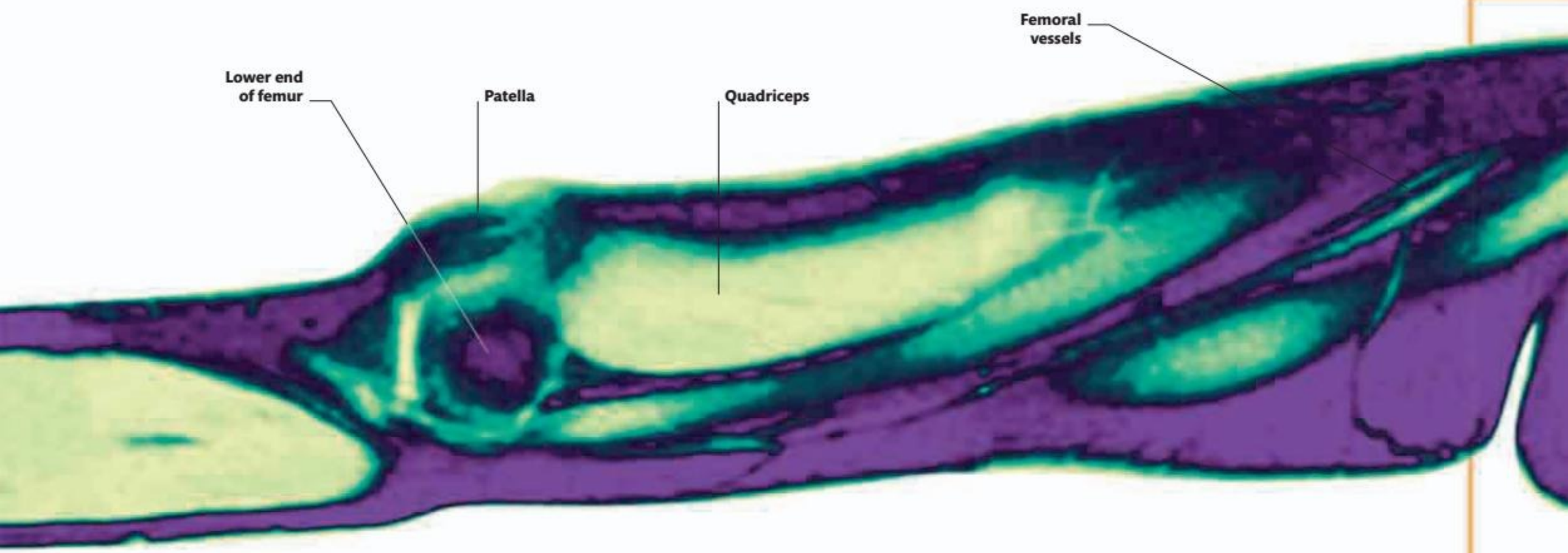


LOWER LIMB AND FOOT

The sequence of axial and transverse sections through the thigh and lower leg show how the muscles are arranged around the bones. Groups of muscles are bound together with fascia—fibrous packing tissue—forming three compartments in the thigh (the flexor, extensor, and adductor muscles), and three in the lower leg (flexor, extensor, and peroneal or fibular muscles). Nerves and deep blood vessels are also packaged together in sheaths of fascia, forming "neurovascular bundles". Section 2 shows the bones of the forefoot, while the tightly packed muscles surrounding the tibia and fibula in the lower leg are visible in section 3. At the knee joint, shown in section 4, the patella can be seen to fit neatly against the reciprocal shape of the femoral condyles. The neurovascular bundle is clearly visible here, at the back of the knee, in a space known as the popliteal fossa—with the hamstring muscles on either side. Sections 5 and 6, through the middle and upper thigh, show the powerful quadriceps and hamstring muscles surrounding the thigh bone, or femur.



LEVELS OF SCANS



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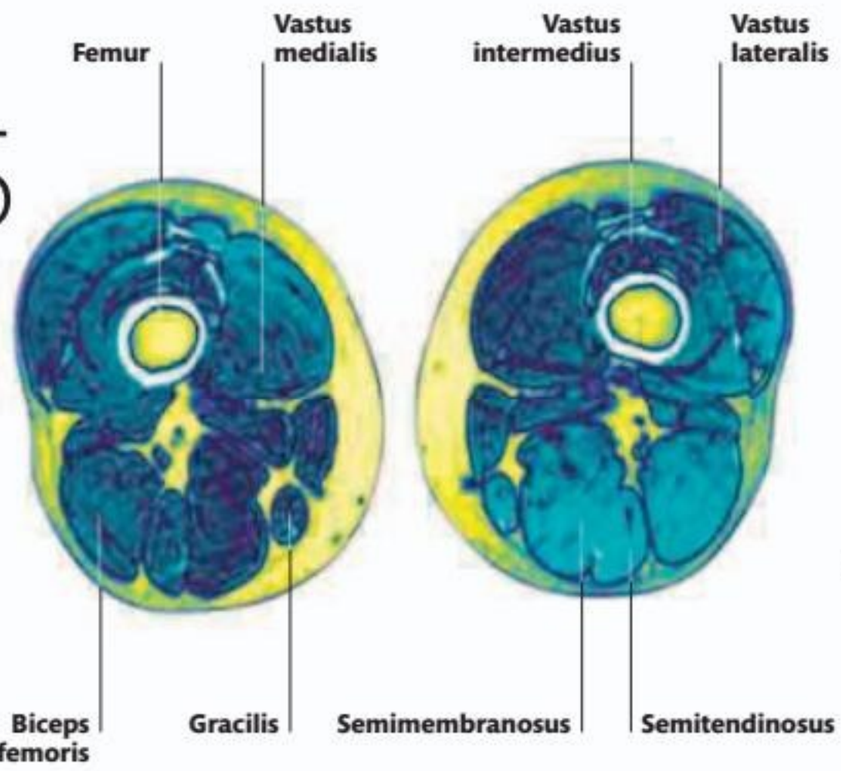

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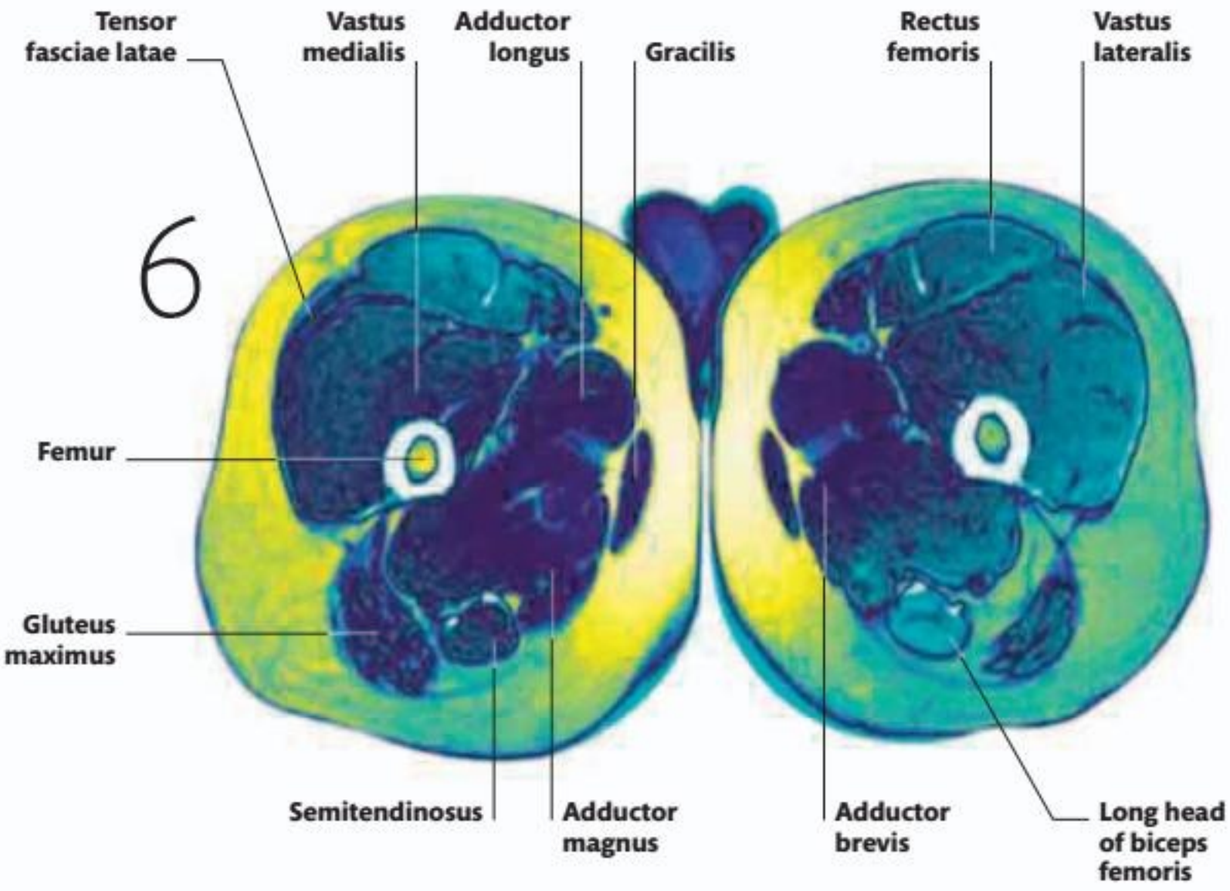

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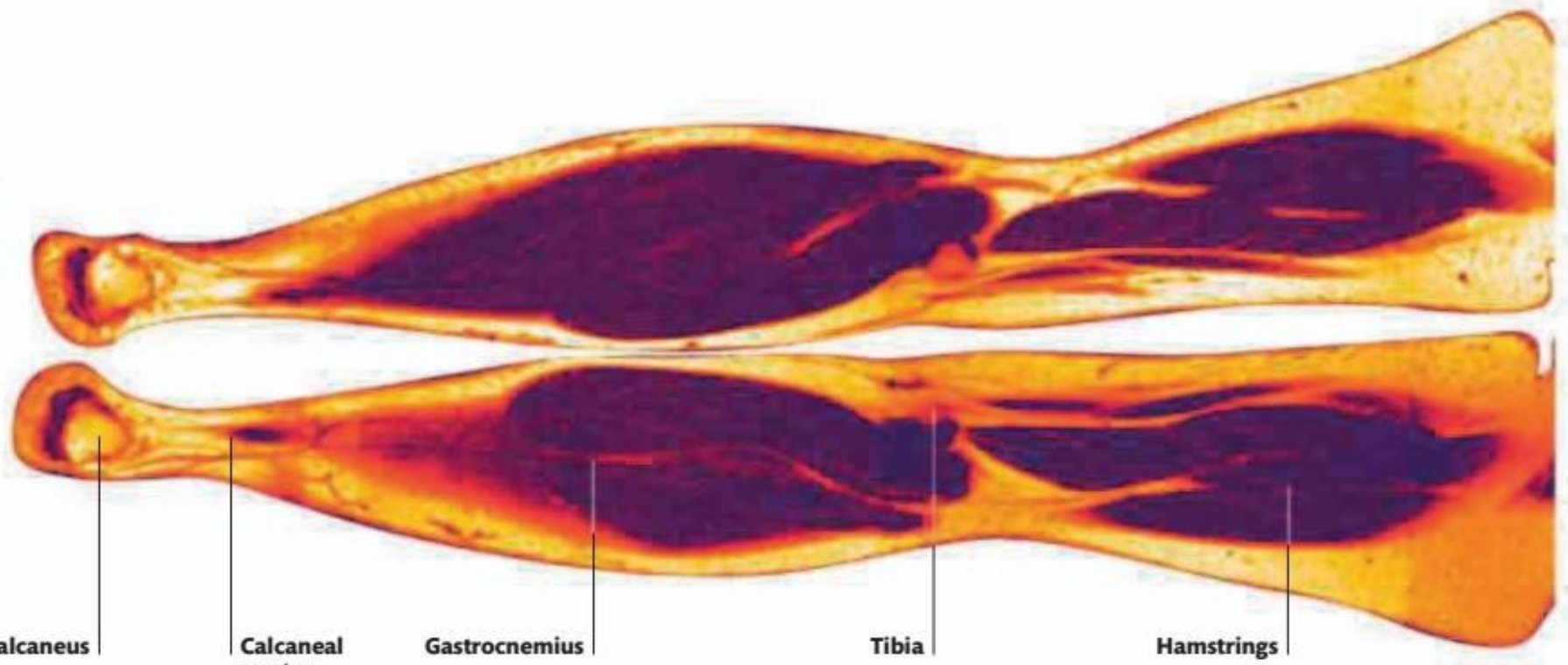

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Glossary

Terms defined elsewhere in the glossary are in italics. All distinct terms are in **bold**.

abduction
The action of moving a limb further from the midline of the body. In muscle names, **abductor** indicates a muscle that has this action. See also *adduction*.

adduction
The action of moving a limb closer to the midline of the body. In muscle names, **adductor** indicates a muscle that has this action. See also *abduction*.

adipose tissue
Fat-storage *tissue*.

adrenal glands
Also called suprarenal glands. A pair of glands found one on top of each kidney. Each gland consists of an outer adrenal cortex, which secretes *corticosteroid hormones*, and an inner adrenal medulla, which secretes *epinephrine*. See also *corticosteroid*.

adrenaline
See *epinephrine*.

afferent
In the case of blood vessels, carrying blood towards an organ, and in *nerves*, conducting impulses towards the *central nervous system*. See also *efferent*.

alveolus (pl. alveoli)
A small cavity; specifically, one of the millions of tiny air sacs in the lungs where exchange of gases with the blood takes place; also the technical term for a tooth socket.

amino acid
Proteins are made from up to 20 different types of these small, nitrogen-containing *molecules*; amino acids also play various other roles in the body. See also *peptide*.

amnion
The *membrane* that encloses the developing *fetus* within the *uterus* (womb). The fluid inside it (amniotic fluid) helps to cushion and protect the fetus.

anastomosis
An interconnection between two otherwise separate blood vessels (e.g. two *arteries*, or an artery and a *vein*).

angio-
A prefix relating to blood vessels.

angiography
In medical imaging: any technique for obtaining images of blood vessels in the living body.

anterior
Toward the front of the body, when considered in a standing position. **Anterior to** means in front of. See also *posterior*.

antibiotic
Any of various chemical compounds, natural or synthetic, that destroy or prevent the growth of microorganisms (e.g. *bacteria*, yeasts, and fungi).

antibody
Defensive *proteins* produced by white blood cells that recognize and attach to particular "foreign" chemical components (*antigens*), such as the surface of an invading *bacterium* or *virus*. The body is able to produce thousands of different antibodies targeted at different invaders and toxins.

aorta
The body's largest *artery*, conveying blood pumped by the left *ventricle* of the heart. It extends to the lower abdomen, where it divides into the two common iliac arteries.

aponeurosis
A flattened, sheetlike *tendon*.

arteriole
A very small *artery*, leading into *capillaries*.

artery
A vessel carrying blood from the heart to the *tissues* and organs of the body. Arteries have thicker, more muscular walls than *veins*.

articular fat pad
In a joint bone, such as the knee, the fatty tissue within the synovial membrane.

articular surface
The part of the long bone where the *epiphysis* forms the joint surface of the bone, which is covered in articular *cartilage*.

articulation
A *joint*, especially but not necessarily one allowing movement; also, a location within a joint where two bones meet in close proximity. A bone in a joint is said to **articulate with** the other bone(s) forming the joint.

ATP
Short for **adenosine triphosphate**, an energy-storing *molecule* used by all living *cells*.

atrium (pl. atria)
Either of the two smaller chambers of the heart that receive blood from the *veins* and pass it on to the corresponding *ventricle*.

autonomic nervous system
The part of the nervous system that controls nonconscious processes such as the activity of the body's *glands* and the muscles of the gut. It is divided into the **sympathetic** nervous system, the roles of which include preparing the body for "fight or flight", and the **parasympathetic nervous system**, which stimulates movement and secretions in the gut, produces erection of the penis during coitus, and empties the bladder.

axon
A wirelike extension of a *nerve cell* (*neuron*) along which electrical signals are transmitted away from the cell.

bacterium (pl. bacteria)
Any member of a large group of single-celled living organisms, some of which are dangerous *pathogens*. Bacterial *cells* are much smaller than animal and plant cells, and lack *nuclei*.

basal ganglia
Groups of *nerve cells* deep in the *cerebrum*; consist of the caudate nucleus, putamen, globus pallidus, and subthalamic nucleus. Functions include controlling movement.

belly (of muscle)
The widest part of a *skeletal muscle*, which bulges further when it contracts.

bile
A yellow-green fluid produced by the liver, stored in the *gallbladder*, and discharged into the intestine via the bile duct. It contains excretory products together with bile acids that help with fat digestion.

biopsy
A sample taken from a living body to test for infection, cancerous growth, etc; also the sampling process.

brachial
Relating to the arm.

brainstem
The lowest part of the brain, leading down from the rest of the brain to the *spinal cord*. In descending order, it consists of the *midbrain*, pons, and *medulla oblongata*.

bronchus (pl. bronchi)
The air tubes branching from the *trachea* and leading into the lungs; right and left main bronchi enter each lung respectively and divide into lobar bronchi, and eventually into much smaller tubes called **bronchioles**.

bursa
A pocket of **synovial fluid** that may lubricate the movement of tendons around joints, such as in the suprapatellar region of the knee joint.

cecum
The first part of the large intestine.
calcitonin. See *thyroid gland*.

cancer
An uncontrolled growth of *cells* with the potential to spread and form colonies elsewhere in the body. Cancer cells typically look different from their noncancerous equivalents under the microscope. Cancers can arise in many different *tissues*.

capillaries
The smallest blood vessels, with a wall only one *cell* thick, supplied by *arterioles* and draining into *veins*. Capillaries form networks, and are the sites where nutrients, gases, and waste products are exchanged between body *tissue* and blood.

carbohydrates
Naturally occurring chemical substances containing carbon, hydrogen, and oxygen atoms, e.g. *sugars*, *starch*, cellulose, and *glycogen*.

cardiac
Relating to the heart.

carpal
Relating to the wrist.

cartilage
A rubbery or tough supportive *tissue* (colloquially "gristle") found in various forms around the body.

cell
A tiny structure containing *genes*, a surrounding fluid (cytoplasm) that carries out chemical reactions, *organelles*, and an enclosing *membrane*. See also *nucleus*.

central nervous system
The brain and *spinal cord*, as distinct from the *nerves* that run through the rest of the body (the *peripheral* nervous system).

central osteonal canal
Also known as the Haversian canal, it is a channel in the center of each *osteon* in a compact bone, containing blood and lymphatic vessels.

cerebellum
An anatomically distinct region of the brain below the back of the *cerebrum*, responsible for coordinating the details of complex bodily movements, and managing balance and posture.

cerebrospinal fluid
The clear fluid that fills the *ventricles* of the brain and surrounds the brain and *spinal cord*, helping to provide a constant environment and acting as a shock absorber.

cerebrum
The largest part of the brain and the locus of most "higher" *mental* activities; part of the forebrain in evolutionary terms. It is divided into two halves called **cerebral hemispheres**.

cervical
1. Relating to the neck.
2. Relating to the *cervix* (neck) of the *uterus*.

cervix
The narrow "neck" of the *uterus*, opening into the upper end of the vagina; widens during childbirth.

cholesterol
A natural chemical that is an essential constituent of the body's *cell membranes* and is an intermediate *molecule* in the production of *steroid hormones*. It is a constituent of the plaques that cause the *arteries* to narrow in atherosclerosis.

chromosomes
The microscopic packages in the *nucleus* of a *cell* that contain genetic information in the form of *DNA*. Humans have 23 pairs of chromosomes, with a complete set present in nearly every cell of the body. Each chromosome consists of a single DNA *molecule* combined with various *proteins*.

cilium (pl. cilia)
A microscopic, beating, hairlike structure found in large numbers on the surfaces of some *cells*—for example in the air tubes of the lungs, where they help to remove foreign particles.

circadian rhythm
An *internal*, daily body rhythm. It is kept accurate by reference to external light and dark.

CNS
Short for *central nervous system*.

cochlea
The complex spiral structure in the *inner ear* that translates sound vibrations in the fluid it contains into electrical impulses to be sent to the brain.

collagen
A tough fibrous, structural *protein* that is widespread in the body (particularly in bone, *cartilage*, blood-vessel walls, and skin).

colon
The main part of the large intestine; comprises the ascending, transverse, and descending colon.

commissure
A link between two structures, especially any of several *nerve tracts* in the brain and *spinal cord* that crosses the midline of the body.

compartment (as in anatomical grouping or area)
In the case of muscles, used to define an anatomically and functionally discrete group of muscles, e.g. flexor compartment of the forearm.

condyle
A rounded, knucklelike projection on a bone that forms part of a *joint*.

connective tissue
Any *tissue* comprising *cells* embedded in an acellular *matrix*; includes *cartilage*, bone, *tendon*, *ligament*, and blood.

cornea
The tough, transparent, protective layer at the front of the eye; helps focus light on the *retina*.

coronal section
A real or imagined section down the body that divides it from side to side; it is perpendicular to a *sagittal section*.

corpus callosum
A large *tract* of *nerve* fibers (*commissure*) that links the brain's two cerebral hemispheres.

cortex
The Latin word for bark, used for the outer parts of some organs, especially:
1. The **cerebral** or **cerebellar cortex** – the surface layers of *cells* (the "gray matter") of these parts of the brain.
2. The **adrenal cortex** – the outer part of the *adrenal glands*.

corticosteroid
Any of several *steroid hormones* produced by the adrenal *cortex*. Examples include **cortisone** and **cortisol** (*hydrocortisone*), which have many effects on the body's *metabolism* and also suppress *inflammation*. The mineral-regulating hormone *aldosterone* is also a corticosteroid.

cranial
1. Relating to the *cranium*.
2. Toward the head.

cranial nerves
Pairs of *nerves* that lead directly from the brain rather than from the *spinal cord*. They mainly supply structures in the head and neck.

cranium
Together with the mandible (jaw), forms the skull.

CSF
Short for *cerebrospinal fluid*.

CT
Short for **computed tomography**, a sophisticated X-ray technique that produces images in the form of "slices" through the patient's body.

cutaneous
Relating to the skin.

cyst
A fluid-filled cavity in the body. Also, an old term for the bladder; hence **cystitis**.

dendrite
A branchlike outgrowth of a *nerve cell* (*neuron*) that carries incoming electrical signals to that cell. A neuron usually has many dendrites.

depressor
Term used in names of several muscles that act to pull down, e.g. depressor anguli oris (pulls down the angle of the mouth). See also *levator*.

diaphragm
A sheet of muscle that separates the *thorax* from the abdomen. When relaxed it is domed upward; it flattens when contracted, to

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increase thoracic volume and draw air into the lungs. It is the most important muscle used in breathing.

diaphysis
A cylinder of compact bone around a central marrow cavity in a long bone.

diffusion
The net movement of *molecules* in a fluid (gas or liquid) from regions of high to lower concentration.

dilated
Opened or stretched wider.

distal
Relatively further away from the center of the body or from the point of *origin*. See also *proximal*.

DNA
Short for **deoxyribonucleic acid**, a very long *molecule* made up of small individual units or nucleotides, containing one of four bases. DNA is found in the *chromosomes* of living *cells*; the order of the bases "spells out" the genetic instructions of the animal. See also *gene*.

dorsal
Relating to the back or back surface of the body, or to the top of the brain; also, relating to the back (**dorsum**) of the hand or the upper surface of the foot.

dorsal (sensory) root ganglion
Part of the *spinal cord* where cell bodies of sensory nerves cluster.

duodenum
The first part of the small intestine, leading out of the stomach.

efferent
In the case of blood vessels, carrying blood away from an organ; in the case of *nerves*, conducting impulses away from the *central nervous system*. See also *afferent*.

electrocardiography
Recording the electrical activity produced by the heart muscle, using electrodes applied to the patient's skin.

embryo
The earliest stage of a developing unborn individual in the *uterus*, from *fertilization* until 8 weeks of gestation (after which it is known as a *fetus*).

endocrine system
The system comprising *glands* that produce *hormones*.

endometrium
The inner lining of the *uterus*.

endosteal blood vessels
Blood vessels that travel inside a compact bone. See also *periosteal blood vessels*.

endothelium
The *cell* layer that forms the inner lining of blood vessels.

enzyme
Any of a large variety of different *molecules* (nearly always *proteins*) that catalyze a particular chemical reaction in the body.

epicondyle
A small bulge found on some bones near a *joint*, usually forming a site for muscle attachment.

epidermis
The outermost layer of skin, with a surface consisting of dead cells packed with the tough *protein keratin*.

epiglottis
A flexible flap of *cartilage* in the throat that helps to cover the *trachea* (windpipe) during swallowing.

epinephrine
A *hormone* released by the *adrenal* glands in response to stressful situations. It prepares the body for a "fight or flight" response by increasing heart rate, diverting blood flow to muscles, etc.

epiphysis
The end of a bone that expands to form a joint surface. It is covered with a relatively thin shell of compact bone and is full of spongy or cancellous bone. See also *metaphysis*.

epithelium
Any *tissue* that forms the surface of an organ or structure. It may consist of a single layer of *cells*, or several layers.

erythrocyte
A red blood *cell*.

extension
The movement that increases the angle of, or straightens, a *joint*. The name **extensor** indicates a muscle that has this action, e.g. extensor digitorum extends the fingers. See also *flexion*.

external
In anatomy: closer to the outer surface.

extracellular
Outside the *cell*; often used in reference to the fluid or *matrix* between cells of a *connective tissue*.

Fallopian tube
Another name for the oviduct or uterine tube; two oviducts attach to the *uterus*, extending to the *ovary* on each side; the *ovum* travels down this tube after *ovulation*.

fascia (pl. fasciae)
Layers of fibrous *tissue* between and around muscles, vessels, and organs.

fascicle
A bundle of muscle fibers, packed in connective tissue called **endomysium** and contained in a sheath of **perimysium**.

fertilization
The union of a *sperm* with an unfertilized egg (*ovum*), the first step in the creation of a new individual. See also *zygote*.

fetus
The unborn individual in the *uterus*, from 8 weeks after *fertilization*, when it begins to show a recognizably human appearance. See also *embryo*.

flexion
The bending movement at a *joint*. The name **flexor** indicates a muscle that has this action, e.g. flexor carpi ulnaris bends the wrist. See also *extension*.

follicle
A small cavity or saclike structure: e.g. the hair follicle from which a hair grows.

foramen
An opening, hole, or connecting passage.

fossa
A shallow depression or cavity.

frontal
Relating to or in the region of the forehead; **frontal bone**, the skull bone of the forehead; **frontal lobe**, the foremost lobe of each cerebral hemisphere, lying behind the forehead.

gallbladder
The hollow organ into which *bile* (formerly known as gall) secreted by the liver is stored and concentrated before being transferred to the intestine.

gamete
A *sperm* or an *ovum* (egg). Gametes contain just one set of 23 *chromosomes*, whereas normal body *cells* have two sets (46 chromosomes). When sperm and egg combine during *fertilization*, the two-set condition is restored. See also *zygote*.

ganglion
1. A concentration of *nerve cell* bodies, especially one outside the *central nervous system*.
2. A swelling on a *tendon* sheath.

gastric
Relating to the stomach.

gene
A length of a *DNA molecule* that contains a particular genetic instruction. Many genes are blueprints for making particular *protein* molecules, while some have a role in controlling other genes. Between them, the thousands of different genes in the body provide the instructions for a fertilized egg to grow into an adult, and for all essential activities of the body to be carried out. Nearly every *cell* in the body contains an identical set of genes, although different genes are "switched on" in different cells.

genome
The complete set of *genes* found in a human or other living species. The human genome is thought to contain about 20,000–25,000 different genes.

gland
A structure in the body, the main purpose of which is to secrete particular chemical substances or fluids. Glands are either **exocrine**, releasing their secretions through a duct onto an *external* or *internal* surface, such as the salivary glands, or **endocrine**, releasing *hormones* into the blood stream. See also *endocrine system*.

glial cells
Cells in the nervous system that are not *neurons* but play various supportive and protective roles within the nervous system.

gloss-, glosso-
Prefixes relating to the tongue.

glucagon
A *hormone* produced by the pancreatic islets (see *pancreas*) that increases *glucose* levels in the blood; its effect is opposite to that of *insulin*.

glucose
A simple *sugar* that is the main energy source used by the body's *cells*.

glycogen
A *carbohydrate* made up of long, branched chains of connected *glucose* molecules. The body stores glucose in the form of glycogen, especially in the muscles and liver; also called **animal starch**.

gonad
An organ that produces sex *cells* (*gametes*) – i.e. an *ovary* or a *testis*. A **gonadotropin** is a *hormone* that specifically affects the gonads.

gray matter
Part of the brain that contains cell bodies of *neurons*. See also *white matter*.

gyrus (pl. gyri)
One of the folds on the outer surface of the brain. See also *sulcus*.

hemoglobin
The red pigment within *erythrocytes* that gives blood its color and carries oxygen to the *tissues*.

head (of a muscle)
Where a muscle has several *origins* or *proximal* attachments, these may be referred to as "heads", as in the long and short heads of biceps brachii.

hepatic
Relating to the liver.

homeostasis
The maintenance of stable conditions in the body, e.g. in terms of chemical balance or temperature.

hormone
A chemical messenger produced by one part of the body that affects other organs or parts. There also exist **local hormones** that affect only nearby *cells* and *tissues*. Chemically, most hormones are either *steroids*, *peptides*, or small *molecules* related to *amino acids*. See also *neurotransmitter*.

hypothalamus
A small but vital region at the base of the brain, which is the control center for the *autonomic nervous system*, regulating processes such as body temperature and appetite. Also controls the secretion of *hormones* from the *pituitary gland*.

ileum
The last part of the small intestine, ending at the junction with the large intestine (*colon*) N.B: Not the same as ilium, one of the bones of the hip.

immune system
The *molecules*, *cells*, organs, and processes involved in defending the body against disease.

immunity
Resistance to attack by a *pathogen* (disease-causing organism); **specific immunity** develops as a result of the body's *immune system* being primed to resist a particular pathogen.

immunotherapy
Any of various treatments involving either the stimulation or suppression of the activity of the immune system.

inferior
Lower down the body, when considered in a standing position (i.e. nearer the feet). See also *superior*.

inflammation
An immediate reaction of body *tissue* to damage, in which the affected area becomes red, hot, swollen, and painful, as white blood cells (see *leukocyte*) accumulate at the site to attack potential invaders.

inguinal
Relating to, or in the region of, the groin.

inner ear
The fluid-filled innermost part of the ear, which contains the organs of balance (the semicircular canals) and the organs of hearing within the *cochlea*. See also *middle ear*.

insertion
The point of attachment of a muscle to the structure that typically moves when the muscle is contracted. See also *origin*.

insulin
A *hormone* produced by the pancreatic islets (see *pancreas*) that promotes the uptake of *glucose* from the blood, and the conversion of glucose to the storage *molecule*, *glycogen*.

integument
The *external* protective covering of the body.

internal
In anatomy: inside the body, distant from the surface. See also *external*.

internal elastic media
The layer between the *tunica media* and *tunica intima* that is prominent in large arteries, including the *aorta* and its main branches. This layer is absent from some *veins*, including those around the brain.

intra-
Prefix meaning within, as in **intracellular** or **intramuscular**.

islets of Langerhans
See *pancreas*.

-itis
Suffix meaning "*inflammation*", used in words such as **tonsillitis** and **laryngitis**.

joint
Any junction between two or more bones, whether or not movement is possible between them. See also *articulation*, *suture*, *symphysis*, *synovial joint*.

keratin
A tough *protein* that forms the substance of hair and nails, gives strength to the skin, etc.

labia (sing. labium)
Either of the two paired folds that form part of the *vulva* in females: the outer **labia majora** and the more delicate inner **labia minora**.

labial
Relating to the lips, or to the *labia* of the female genitals.

lactation
Secretion of milk by the breasts.

larynx
The voicebox: a complex structure situated at the top of the *trachea* (windpipe). It includes the **vocal cords**, structures that function to seal off the trachea when necessary, as well as creating sound when their edges are made to vibrate during breathing.

lateral
Relating to or toward the sides of the body. See also *medial*.

leukocyte
A white blood *cell*. There are several types, acting in different ways to protect the body against disease as part of its *immune response*. Leukocytes are found in *lymph nodes* and other *tissues* generally, as well as in the blood.

levator
Term used in the names of several muscles whose action is to lift up, such as the levator scapula (lifts the shoulder blade). See also *depressor*.

ligament
A tough fibrous band that holds two bones together. Many ligaments are flexible, but they cannot be stretched. The term

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is also used for bands of *tissue* connecting or supporting some internal organs.

limbic system
Several connected regions at the base of the brain, involved in memory, behavior, and emotion.

line of fusion
A line in the bone that shows the area of fusion of the cartilage growth plate with a long bone. The cartilage plate allows long bones to grow quickly in length during childhood and fuses by adulthood, but the line of fusion may still be evident for a few years.

lingual
Relating to the tongue.

lipid
Any of a large variety of fatty or fatlike substances that are found naturally in living things and are relatively insoluble in water.

lumbar
Relating to the lower back and sides of the body between the lowest ribs and the top of the hip bone. The **lumbar vertebrae** are the *vertebrae* that lie within this region.

lumen
The space inside a tubular structure, such as a blood vessel or glandular duct.

lymph node
A small lymphoid organ; lymph nodes serve to filter out and dispose of *bacteria* and debris, such as *cell* fragments.

lymphocyte
A specialized *leukocyte* that produces antibodies including *natural killer cells*, T cells, and B cells.

lymphoid tissue
The *tissue* of the lymphatic system, which has an immune function, including *lymph nodes*, the *thymus*, and the *spleen*.

M line
A fine line present in skeletal muscle, which connects the thick myosin filaments and holds them in place. See also *Z disc*.

macromolecule
A large *molecule*, especially one that consists of a chain of small similar "building blocks" joined together. *Proteins, DNA, and starch* are examples of macromolecules.

mammary
Of, or relating to, the breasts.

marrow
In anatomical contexts, usually short for **bone marrow**, the soft material located in the cavities of bones; in some areas this *tissue* is mainly fat; in others, it is blood-forming tissue.

matrix
The *extracellular* material in which the cells of *connective tissues* are embedded. It may be hard, as in bone; tough, as in *cartilage*; or fluid, as in blood.

meatus
A channel or passage. For example, the *external* **auditory meatus**, the ear canal.

medial
Toward the midline of the body. See also *lateral*.

medullary (marrow) cavity
Cavities of long bones that are filled with blood-forming red marrow at birth, but this is replaced with fat-rich yellow marrow by adulthood. Red marrow persists in other parts such as the skull, spine, ribs, and pelvis.

medulla
1. Short for **medulla oblongata**, the elongated lower part of the brain that connects with the *spinal cord*.
2. The central part or core of some organs such as the kidneys and *adrenal glands*.

melanin
A dark brown naturally occurring pigment *molecule*, which occurs in greater amounts in tanned or darker skin, and protects deeper *tissues* from ultraviolet radiation.

melatonin
A *hormone* secreted by the pineal *gland* in the brain, which plays a role in the body's sleep–wake cycle (see *circadian rhythm*).

membrane
1. A thin sheet of *tissue* covering an organ, or separating one part of the body from another.
2. The outer covering of a *cell* (and similar structures within the cell). A cell membrane is composed of a double layer of *phospholipid molecules* with other molecules such as *proteins* embedded in it.

meninges
Membranes that enclose the outside of the brain and *spinal cord*. **Meningitis** is *inflammation* of the meninges, usually resulting from infection.

meniscus (pl. menisci)
Crescent-shaped articular disc made of fibrocartilage present in the knee joint. A pair of menisci facilitates the complex movements of this joint.

menstrual cycle
The monthly cycle that takes place in the *uterus* of a non-pregnant woman of reproductive age. The *endometrium* (lining of the uterus) grows thicker in preparation for possible pregnancy; an egg is released from the ovary (*ovulation*); then, if the egg is not fertilized, the endometrium breaks down and is discharged through the vagina in a process known as **menstruation**.

mental
1. Relating to the mind (Latin *mens*).
2. Relating to the chin (Latin *mentum*).

mesentery
A folded sheet of *peritoneum* (the *membrane* lining the abdominal cavity and organs), forming a connection between the intestines and the back of the abdominal cavity.

metabolism
The chemical reactions taking place in the body. The **metabolic rate** is the overall rate at which these reactions are occurring.

metaphysis
Neck of a long bone where spongy bone starts to encroach on marrow cavity. See also *epiphysis*.

midbrain
The upper part of the *brainstem*.

middle ear
The air-filled middle chamber of the ear, between the inner surface of the eardrum and the *inner ear*. See also *ossicles*.

molecule
The smallest unit of a chemical compound that can exist, consisting of two or more atoms joined together by chemical bonds. The water molecule is a simple example, consisting of two hydrogen atoms joined to one oxygen atom. See also *macromolecule*.

motor
Adjective relating to the control of muscle movements, as in **motor neuron**, **motor function**, etc. See also *sensory*.

MRI scan
Short for **magnetic resonance imaging scan**, a medical imaging technique based on the energy released when magnetic fields are applied then removed from the body; it can produce very detailed images of the soft *tissues* of the body.

mucosa (pl. mucosae)
A *membrane* that secretes *mucus*.

mucus
A thick fluid produced by some *membranes* of the body for protection, lubrication, etc. (Adjective mucous.)

muscle fiber
Cylindrical units in a skeletal muscle that range from a few millimeters to several centimeters in length. They are formed by the merging of many *cells*, and therefore contain many nuclei.

myelin
Fatty substance forming a layer around some *nerve axons*, called **myelinated** axons, insulating them and speeding their nerve impulses.

myelo-
1. Prefix relating to the *spinal cord*.
2. Prefix relating to bone *marrow*.

myo-
Prefix relating to muscle.

myofibril
Fibers in *skeletal muscle* that contain filaments made of contractile proteins, mainly **actin** and **myosin**. The way these filaments are organized gives *skeletal muscle* a striped or striated appearance under a light microscope.

natural killer (NK) cell
A type of *lymphocyte* that can attack and kill *cancer cells* and *virus*-infected cells.

neocortex
All the *cortex* of the *cerebrum* except the region concerned with smell and the hippocampal formation.

nerve
A cablelike structure transmitting information and control instructions in the body. A typical nerve consists of *axons* of many separate nerve *cells* (*neurons*) running parallel to, but insulated from, each other; the nerve itself is surrounded by an overall protective sheath of fibrous *tissue*. Nerves may contain nerve fibers controlling muscles or *glands* (*efferent* fibers), while others contain fibers carrying *sensory* information back to the brain (*afferent* fibers); some nerves carry both types of nerve fiber.

neuron
A *nerve cell*. A typical neuron consists of a rounded cell body; branchlike outgrowths called *dendrites* that carry incoming electrical signals to the neuron; and a single, long, wirelike extension, called an *axon*, which transmits outgoing messages. There are many variations on this basic pattern, however.

neurotransmitter
Any of various chemical substances released at *synapses* by the ends of *nerve cells*, where they function to pass a signal on to another nerve cell or muscle. Some neurotransmitters act mainly to stimulate the action of other cells, others to inhibit them.

nucleus (pl. nuclei)
1. The structure within a *cell* that contains the *chromosomes*.
2. Any of various concentrations of *nerve* cells within the *central nervous system*.
3. The central part of an atom.

occipital
Relating to the back of the head. The **occipital bone** is the skull bone forming the back of the head. The **occipital lobe** is the most posterior lobe of each cerebral hemisphere, lying below the occipital bone.

esophagus
The gullet: the tubular part of the alimentary canal between the *pharynx* and the stomach.

estrogens
Steroid hormones produced predominantly by the *ovary*, and which regulate female sexual development and *physiology*. Artificial estrogens are used in *oral* contraceptives and hormone replacement therapy.

olfactory
Relating to the sense of smell.

oligodendrocyte
A structure in nerve cell that manufactures the *myelin* sheath along the axons in the central nervous system.

optic nerve
The *nerve* that transmits visual information from the *retina* of the eye to the brain.

oral
Relating to the mouth.

orbit
The bony hollow in the skull within which the eye is contained.

organelle
Any of a variety of small structures inside a *cell*, usually enclosed within a *membrane*, which are specialized for functions such as energy production or secretion.

origin
The point of attachment of a muscle to the structure that typically remains stationary when the muscle is contracted. See also *insertion*.

ossi-, osteo-
Prefixes relating to bone.

ossicles
Three small bones of the *middle ear* that transmit vibrations caused by sound waves from the eardrum to the *inner ear*.

osteocyte
Bone cells that lie in minute cavities between the concentric, cylindrical layers of bone mineral. The *cells* communicate with each other via thin processes, which run through microscopic canals in the mineral.

osteon
The basic unit in compact bone. It consists of concentric layers of *tissue*.

ovary
Either of the two organs in females that produce and release egg *cells* (*ova*). They also secrete sex *hormones*.

ovulation
The point in the *menstrual* cycle at which an egg *cell* (*ovum*) is released from the *ovary* and begins to travel toward the *uterus*.

ovum (pl. ova)
An unfertilized egg *cell*.

palate
The roof of the mouth, comprising the bony **hard palate** in the front and the muscular **soft palate** behind it.

pancreas
A large, elongated *gland* lying behind the stomach, with a dual role in the body. The bulk of its *tissue* secretes digestive *enzymes* into the *duodenum*, but it also contains scattered groups of cells called **pancreatic islets** or *islets of Langerhans* that produce important *hormones*, including *insulin* and *glucagon*.

parasympathetic nervous system
See *autonomic nervous system*.

parathyroid glands
Four small *glands* that are often embedded in but are separate from the *thyroid gland*. They produce parathyroid hormone, which regulates calcium *metabolism* in the body.

parietal
A term (derived from the Latin word for "wall") with various applications in anatomy. The **parietal bones** form the side walls of the skull, and the **parietal lobes** of the brain lie beneath those bones. *Membranes* (such as the *pleura* and *peritoneum*) are described as parietal where they are attached to the body wall.

pathogen
Any disease-causing agent, including *bacteria* and *viruses*.

pathology
The study of disease; also, the physical manifestations of a disease.

pelvic girdle
The hip bones attach to the sacrum to form the pelvic girdle, linking the leg bones to the spine.

pelvis
1. The cavity enclosed by the *pelvic girdle*, or the area of the body containing the pelvic girdle.
2. The **renal pelvis** is the cavity in the kidney where the urine collects before passing down the *ureter*.

peptide
Any *molecule* consisting of two or more *amino acids* joined together, usually in a short chain. There are many types, some of which are important *hormones*. Proteins are polypeptides: long chains of amino acids.

peri-
Prefix meaning round or surrounding.

periosteal blood vessels
The blood vessels that run around the outside of the compact bone. See also *endosteal blood vessels*.

periosteum
The outer lining of bones; contains cells that can lay down or remove bone tissue.

peripheral
Toward the outside of the body or to the extremities of the body. The term **peripheral nervous system** refers to the entire nervous system except for the brain and *spinal cord*. See also *central nervous system*.

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peritoneum
A thin, lubricated sheet of *tissue* that enfolds and protects most of the organs of the abdomen.

pharynx
The muscular tube behind the nose, mouth, and *larynx*, leading into the *esophagus*.

phospholipid
A type of *lipid molecule* with a phosphate (phosphorus plus oxygen) group at one end. The phosphate group is attracted to water while the rest of the molecule is not. This property makes phospholipids ideal for forming *cell* membranes if two layers of molecules are situated back-to-back.

physiology
The study of the normal functioning of body processes; also, the body processes themselves.

pituitary gland
Also called the **hypophysis**, a complex pea-sized structure at the base of the brain, sometimes described as the body's "master *gland*". It produces various *hormones*, some affecting the body directly and others controlling the release of hormones by other glands.

placenta
The organ that develops on the inner wall of the *uterus* during pregnancy, allowing the transfer of substances, including nutrients and oxygen, between maternal and fetal blood. See also *umbilical cord*.

plasma
Blood minus its cellular components (red and white blood *cells*, and *platelets*).

platelets
Specialized fragments of *cells* that circulate in the blood and are involved in blood clotting.

pleura (pl. pleurae)
The lubricated *membrane* that lines the inside of the thoracic cavity and the outside of the lungs.

plexus
A network, usually in reference to *nerves* or blood vessels.

pneum-, pneumo-
1. Prefix relating to air.
2. Prefix relating to the lungs.

portal vein
The large *vein* carrying blood from the intestines to the liver; previously known as the **hepatic portal vein**.

posterior
Toward the back of the body, when considered in a standing position. **Posterior to**, behind. See also *anterior*.

process
In anatomy: a projection or extended part of a bone, *cell*, etc.

progesterone
A *steroid hormone* produced by the *ovaries* and *placenta*, which plays a role in the *menstrual cycle* and in the maintenance and regulation of pregnancy.

pronation
The rotation of the radius around the ulna in the forearm, turning the palms of the hand to face downward or backward. In muscle names, **pronator** indicates a muscle that has this action, e.g. pronator teres. See also *supination*.

prostate gland
A *gland* located below the male bladder; its secretions contribute to *semen*.

proteins
Large *molecules* consisting of long folded chains of small linked units (*amino acids*). There are thousands of different kinds in the body. Nearly all *enzymes* are proteins, as are the tough materials *keratin* and *collagen*. See also *peptide*.

proximal
Relatively closer to the center of the body or from the point of *origin*. See also *distal*.

puberty
The period of sexual maturation between childhood and adulthood.

pulmonary
Relating to the lungs.

pyloric
Relating to the last part of the stomach, or pylorus. The muscle wall of the end of the pylorus is thickened to form the **pyloric sphincter**.

receptor
1. Any sense organ, or the part(s) of a sense organ that collects information.
2. A *molecule* in a *cell*, or on a cell's outer *membrane*, that responds to an outside stimulus, such as a *hormone* molecule attaching to it.

rectum
The short final portion of the large intestine, connecting it to the anal canal.

rectus
In muscle names, a straight muscle.

reflex
An involuntary response in the nervous system to certain stimuli, for example the "knee-jerk" response. Some reflexes, called **conditioned reflexes**, can be modified by learning.

renal
Relating to the kidneys.

respiration
1. Breathing.
2. Also called cellular respiration, the biochemical processes within cells that break down fuel *molecules* to provide energy, usually in the presence of oxygen.

retina
The light-sensitive layer that lines the inside of the eye. Light falling onto *cells* in the retina stimulates the production of electrical signals, which are transmitted to the brain via the *optic nerve*.

ribosomes
Particles within *cells* involved in *protein* synthesis.

RNA
Short for **ribonucleic acid**, a long *molecule* similar to *DNA*, but usually single- rather than double-stranded. RNA has many important roles including making copies of the DNA code for *protein* synthesis.

sacral
Relating to or in the region of the **sacrum**, the bony structure made up of fused *vertebrae* at the base of the spine that forms part of the *pelvic girdle*.

sagittal section
A real or imagined section down the body, or part of the body, that divides it into right and left sides.

sarcoplasm
The **cytoplasm** of muscle cell; contains many nuclei.

scrotum
The loose pouch of skin holding the *testes* in males.

sebum
An oily, lubricating substance secreted by sebaceous *glands* in the skin.

semen
The fluid released through the penis when the male ejaculates; it contains *sperm* and a mixture of nutrients and salts. Also called **seminal fluid**.

sensory
Concerned with transmitting information coming from the sense organs of the body.

serous membrane
A type of body *membrane* that secretes lubricating fluid and envelops various internal organs and body cavities. The pericardium, *pleura*, and *peritoneum* are all serous membranes.

sinus
A cavity; especially: 1. One of the air-filled cavities in the bones of the face that connect to the nasal cavity.
2. An expanded portion of a blood vessel, for example the carotid sinus and coronary sinus.

skeletal muscle
A type of muscle also known as *voluntary* or *striated muscle*, usually under voluntary control. Appears striped under the microscope. Many —but not all—skeletal muscles attach

to the skeleton, and are important in movement of the body. See also *smooth muscle*.

smooth muscle
Muscle *tissue* that lacks stripes when viewed under a microscope, in contrast to *striated muscle*. Smooth muscle is found in the walls of internal organs and structures, including blood vessels, the intestines, and the bladder. It is not under conscious control, but controlled by the *autonomic nervous system*.

somatic
1. Of or relating to the body, e.g. somatic cells.
2. Relating to the body wall.
3. Relating to the part of the nervous system involved in voluntary movement and sensing the outside world.

somatosensory
Related to sensations received from the skin and internal organs, including senses such as touch, temperature, pain, and awareness of *joint* position, or proprioception.

sperm
A male sex *cell* (*gamete*), equipped with a long moving "tail" (flagellum) to allow it to swim toward and fertilize an egg in the body of the female. Colloquially the word is also used to mean *semen*.

sphincter
A ring of muscle that allows a hollow or tubular structure in the body to be drawn closed (e.g. the *pyloric* sphincter and anal sphincter).

spinal cord
The part of the *central nervous system* that extends down from the bottom of the brain through the vertebral column, which protects it. Most *nerves* that supply the body originate in the spinal cord.

spinal nerve
A nerve in the *central nervous system* that is formed by the merging of the sensory and motor nerve rootlets.

spleen
A structure in the abdomen composed of *lymphoid tissue*. It has various roles, including blood storage.

starch
A plant *carbohydrate* made up of long, branched chains of *glucose molecules* linked together.

stem cell
A *cell* in the body that can divide to give rise to more cells. This could be either more stem cells, or a range of more specialized types of cell. Stem cells contrast with highly specialized cells, which play specific roles in the body, and which may have lost the ability to divide completely – such as *nerve* cells.

steroids
Substances that share a basic molecular sturcture, consisting of four rings of carbon atoms fused together. Steroids, which may be naturally occurring or synthetic, are classified as *lipids*. Many of the body's *hormones* are steroids, including *estrogen*, *progesterone*, *testosterone*, and cortisol.

striated muscle
A muscle with *tissue* that presents a striped appearance under a microscope. Striated muscle includes *skeletal muscles* and *cardiac* (heart) muscle. See also *smooth muscle*.

sucrose
See *sugar*.

sugar
1. Commonly used foodstuff, also called *sucrose*.
2. Any of a number of naturally occurring substances that are similar to sucrose. They are all *carbohydrates* with relatively small *molecules*, in contrast to other carbohydrates that are *macromolecules*, such as *starch*.

sulcus (pl. sulci)
One of the grooves on the folded outer surface of the brain. See also *gyrus*.

superficial
Near the surface; **superficial to**, nearer the surface than. (Opposite term **deep**.)

superior
Higher up the body, when considered in a standing position. See also *inferior*.

supination
The rotation of the radius around the ulna in the forearm, turning the palms of the hand to face upward or forward. The opposite to *pronation*. In muscle names, **supinator** indicates a muscle having this action, e.g. the supinator of the forearm.

suprarenal gland
See *adrenal glands*.

suture
1. A stitched repair to a wound.
2. A rigid joint between two bones, as between the bones of the skull.

sympathetic nervous system.
See *autonomic nervous system*.

symphysis
A cartilaginous *joint* between two bones, containing fibrocartilage.

synapse
A close contact between two nerve cells (neurons) allowing signals to be passed from the end of the first neuron on to the next. Synapses can either be electrical (where the information is transmitted electrically) or chemical (where neurotransmitters are released from one neuron to stimulate the next one). Synapses also exist between nerves and muscles.

synovial cavity
Cavity in a joint that is filled with a thin film of lubricating **synovial fluid**.

synovial joint
A lubricated, movable *joint*, such as the knee, elbow, or shoulder. In synovial joints the ends of the bones are covered with smooth *cartilage* and lubricated by a slippery liquid known as **synovial fluid**.

systemic
Relating to or affecting the body as a whole, not just one part of it. The **systemic circulation** is the blood circulation supplying all of the body apart from the lungs.

systole
The part of the heartbeat where the *ventricles* contract to pump blood.

tarsal
1. Relating to the ankle.
2. One of the bones of the tarsus, the part of the foot between the tibia and fibula, and the metatarsals.

temporal
Relating to the temple – the area on either side of the head. The **temporal bones** are two bones, one on each side of the head, that form part of the *cranium*. The **temporal lobes** of the brain are located roughly below the temporal bones.

tendon
A tough fibrous cord that attaches one end of a muscle to a bone or other structure. See also aponeurosis.

testis (pl. testes)
Either of the pair of organs in men that produce male sex cells (sperm). They also secrete the sex hormone testosterone.

testosterone
A *steroid hormone* produced mainly in the testes, which promotes the development of and maintains male bodily and behavioral characteristics.

thalamus
Paired structures deep within the brain, forming a relay station for *sensory* and *motor* signals.

thick filament
Structure in the center of the anisotropic or **A band** in skeletal muscle that is composed of the protein myosin. See also *M line*.

thin filament
Structure in the center of the **A band** in skeletal muscle, which is mainly composed of protein actin. See also *tropomyosin*.

thorax
The chest region, which includes the ribs, lungs, heart, etc.

thymus
A *gland* in the chest composed of *lymphoid tissue*. Largest and most

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active in childhood, its roles include the maturation of T-lymphocytes.

thyroid gland
An endocrine *gland* located at the front of the throat, close to the *larynx* (voicebox). Thyroid *hormones* such as **thyroxin** are involved in controlling *metabolism*, including regulating overall metabolic rate. The hormone *calcitonin*, which helps regulate the body's calcium, is also secreted by the thyroid.

tissue
Any type of living material in the body that contains distinctive types of cells, usually together with *extracellular* material, performing a specific function. Examples of tissues include bone, muscle, *nerve*, and *connective tissue*.

trachea
The windpipe: the tube leading between the *larynx* and the *bronchi*. It is reinforced by rings of *cartilage* to keep it from collapsing.

tract
An elongated structure or connection that runs through a certain part of the body. In the *central nervous system*, the term is used instead of *nerve* for bundles of nerve fibers that connect different body regions.

transmitter
See *neurotransmitter*.

tropomyosin
Actin-bonding protein that is present in the *thin filament* of skeletal muscle.

tunica adventitia
The outermost coat of a blood vessel, which is composed of connective tissue and elastic fibers. See also *tunica intima* and *tunica media*.

tunica intima
The innermost lining of an artery; made up of a single layer of flattened cells, also known as the *endothelium*. Also present in veins. See also *tunica media* and *tunica adventitia*.

tunica media
Middle layer of muscle cells that is thinner in veins than in arteries. See also *tunica intima* and *tunica adventitia*.

umbilical cord
The cord that attaches the developing *fetus* to the *placenta* of the mother, within the *uterus*. Blood from the fetus passes through blood vessels inside the cord, transporting nutrients, dissolved gases, and waste products between the placenta and the fetus.

urea
A small nitrogen-containing *molecule* formed in the body as a convenient way of getting rid of other nitrogen-containing waste products. It is excreted in the urine.

ureter
Either of two tubes that convey urine from the kidneys to the bladder.

urethra
The tube that conveys urine from the bladder to the outside of the body; in men it also conveys *semen* during ejaculation.

uterus
The womb, in which the *fetus* develops during pregnancy.

valve
In a *vein*, a pocketlike structure that allows deoxygenated blood to flow only toward the heart and prevents its backflow into cells. In the heart, it is present in each of the two *atria* and helps to direct the flow of blood in the chambers.

vascular system
The network of *arteries*, *veins*, and *capillaries* that conveys blood around the body.

vaso-
Prefix relating to blood vessels.

vein
A vessel carrying blood from the *tissues* and organs of the body back to the heart.

ventral
Relating to the front of the body, or the bottom of the brain.

ventricle
1. Either of the two larger muscular chambers of the heart. The right ventricle pumps blood to the lungs to be oxygenated, while the stronger-muscled left ventricle pumps oxygenated blood to the rest of the body. See also *atrium*.
2. One of the four cavities in the brain that contain *cerebrospinal fluid*.

venule
A very small vein, carrying blood away from *capillaries*.

vertebra (pl. vertebrae)
Any of the individual bones forming the **vertebral column** or spine.

villi (sing. villus)
Small, closely packed, fingerlike protrusions on the lining of the small intestine, giving the surface a velvety appearance and providing a large surface area, which is essential for the absorption of nutrients.

virus
A tiny parasite that lives inside *cells*, often consisting of only a length of *DNA* or *RNA* surrounded by *protein*. Viruses are much smaller than cells, and operate by "hijacking" cells to make copies of themselves. They are unable to replicate by themselves. Many viruses are dangerous *pathogens*.

viscera
Another term for organs. The adjective **visceral** applies to *nerves* or blood vessels, for example, that supply these organs.

vitamin
Any of a variety of naturally occurring substances that are essential to the body in small amounts, but which the body cannot make itself and so must obtain from the diet.

voluntary muscle
See *skeletal muscle*.

vulva
The outer genitalia of females, comprising the entrance to the vagina and surrounding structures.

white matter
Present in the brain and *spinal cord*, and made up of the axons of neurons. See also *gray matter*.

whole muscle
Part of the *skeletal muscle* that is made up of **fasciculi** and covered in a layer of *fascia* (fibrous tissue) called **epimysium**.

Z disc
Present in the center of the isotropic or **I band** in skeletal muscle; it anchors the *thin filaments*. See also *M line*.

zygote
A cell formed by the union of two *gametes* at *fertilization*.

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